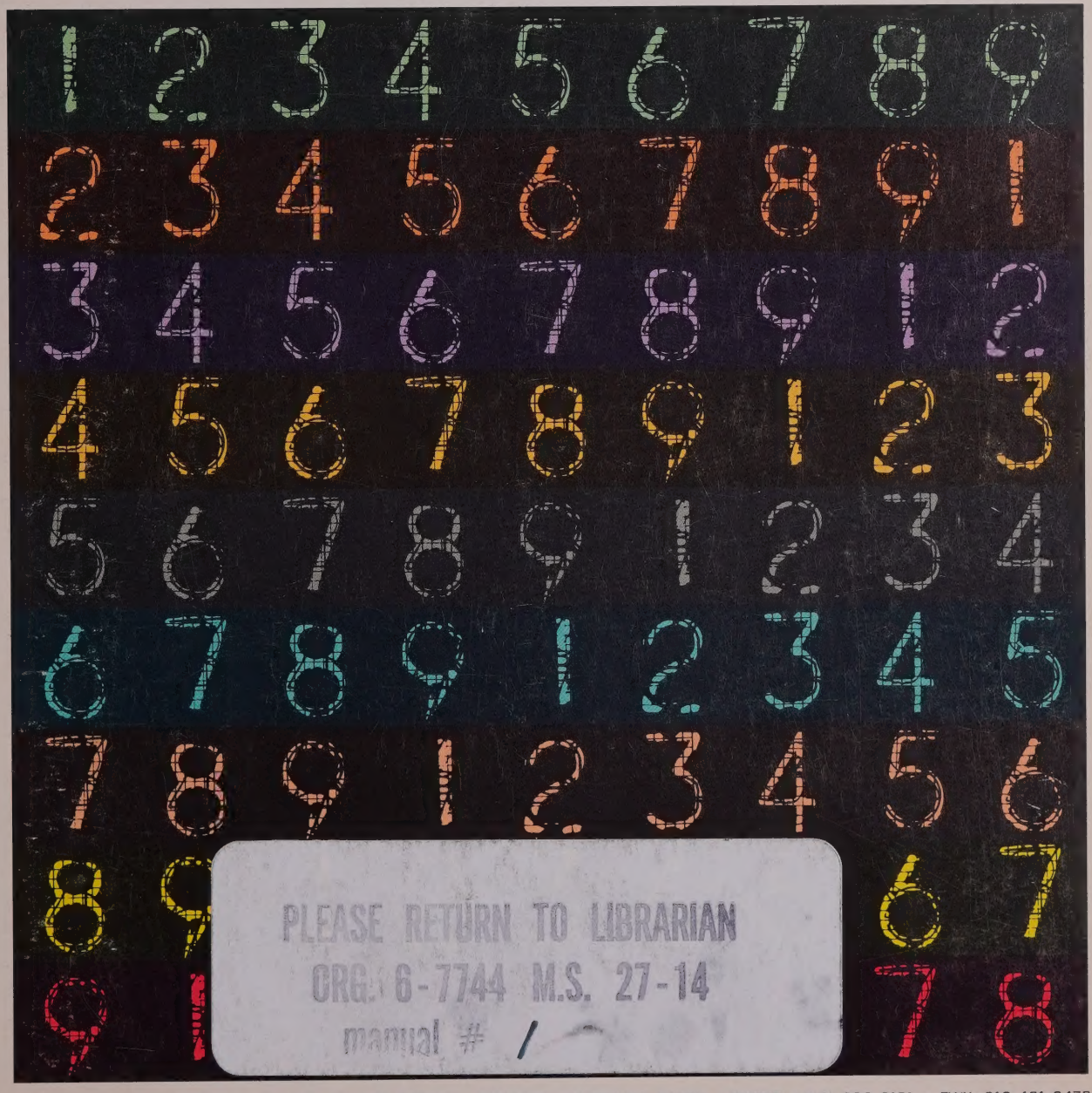
COUNTER / TIMER

INSTRUCTION MANUAL

SD 7014
20 MHz Counter



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MODEL SD 7014

20 MHz COUNTER

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TABLE OF CONTENTS

		PAGE
CHAPTER 1 -	GENERAL INFORMATION	
1.1	Basic Functions	1-1
1.2	Standard Features	1-1
1.3	Applications	1-1
1.4	Optional Features	1-1
1.5	Specifications	1-1
1.6	Recommdnded Test Equipment	1-3
1.7	Preparation for Reshipment	1-4
CHAPTER 2 -	INSTALLATION	
2.1	Installation	2-1
2.2	Inspection and Adjustment	2-1
CHAPTER 3 -	OPERATION	
3.1	Preparation for Use	3-1
3.2	Controls, Indicators, and Connectors	3-1
3.2.1	Recycle Rate Control	3-1
3.2.2	Gate Indicator	3-1
3.2.3	Function Switch	3-1
3.2.4	Readout Indicators	3-1
3.2.5	Input Attenuator	3-1
3.2.6	Trigger Level Control	3-1
3.2.7	Annunciator Assembly	3-1
3.2.8	AC-DC Switch	3-1
3.2.9	Input Connector	3-3
3.2.10	Reset Pushbutton	3-3
3.2.11	114v/230v Line Switch	3-3
3.2.13	Storage On/Off Switch	3-3
3.2.14	Reset Connector	3-3
3.2.15	BCD Output Connector (Optional)	3-3
3.2.16	NORM/TIM Switch	3-3
3.2.17	Int-Ext One MHz Switch	3-3
3.2.18	Freq. Adj. (Coarse, Fine)	3-3
3.3	Accuracy of Measurement	3-3
3.3.1	Oscillator Stability	3-3
3.3.2	Gating Error	3-4
3.3.3	Count Error Produced by Noise in Frequency Measurement	3-5
3.3.4	Loading Error	3-5
3.3.5	Trigger Error	3-5
3.4	Equipment Operation	3-6
3.4.1	Test Function	3-6

TABLE OF CONTENTS (cont)

		PAGE
CHAPTER 3 - OPERATION (cont)		
3.4.2	Frequency (RATE) Measurements	3-7
3.4.3	Count (Totalize) Measurements	3-7
3.4.4	Hold Function	3-7
3.4.5	Time Interval Measurements	3-7
3.4.6	Period Measurements	3-8
3.4.7	Ratio Measurements	3-8
CHAPTER 4 - MAINTENANCE/CALIBRATION		
4.1	Factory Service	4-1
4.2	Routine Maintenance	4-1
4.3	Printed-Circuit Board Repair	4-1
4.4	Parts Location	4-2
4.5	Operational Test Procedure	4-2
4.6	Calibration Procedure	4-5
CHAPTER 5 - THEORY OF OPERATION		
5.1	General Theory of Operation	5-1
5.2	Basic Circuits	5-1
5.3	Circuit Descriptions	5-1
5.3.1	Power Supply	5-1
5.3.2	Input Amplifier and Shaper	5-2
5.3.3	Count Gates	5-2
5.3.4	Count and Display	5-3
5.3.4.1	Indicator Logic Section	5-3
5.3.4.2	Readout and Drivers Section	5-3
5.3.4.3	Off-Scale Indicator	5-3
5.3.5	One Megahertz Clock	5-4
5.3.6	Time Base Logic	5-4
5.3.7	Control and Reset	5-5
5.3.7.1	Count Gate Control	5-5
5.3.8	Timing Pulses	5-6
CHAPTER 6 - PARTS IDENTIFICATION		
	PARTS LISTS	
	Time Base Logic PC Assembly Part Number 25365	6-1
	Power Supply PC Assembly Part Number 25418	6-1
	Count Gates PC Assembly Part Number 25373	6-1
	1 MHz Clock PC Assembly Part Number 25671	6-2

TABLE OF CONTENTS (cont)

	PAGE
CHAPTER 6 - PARTS IDENTIFICATION (cont)	
PARTS LISTS (cont)	
7 Digit PC Assembly Part Number 25369	6-2
Amplifier and Shaper Assembly Part Number 25393	6-3
Control and Reset PC Assembly Part Number 25401	6-4
SD 7014 Final Assembly Part Number 24660	
LOCATION DIAGRAMS AND SCHEMATICS	
One MHz Clock, Parts Location Diagram	6-6
One MHz Clock, Schematic 25670	6-7
Time Base, Parts Location Diagram	6-8
Time Base, Schematic 25362	6-9
Control-Reset, Parts Location Diagram	6-10
Control-Reset, Schematic 25398	6-11
Amplifier-Shaper, Parts Location Diagram	6-12
Amplifier-Shaper, Schematic 25345	6-13
Count Gates, Parts Location Diagram	6-14
Count Gates, Schematic 25370	6-15
Display-Readout, Parts Location Diagram	6-16
Display-Readout, Schematic 25366	6-17
Power Supply, Parts Location Diagram	6-18
Power Supply, Schematic 25415	6-19
SD 7014 Block Diagram (Dwg. 25697)	6-20

LIST OF FIGURES

FIGURE 1	SD 7014 Front Panel	3-2
FIGURE 2	SD 7015 Rear Panel	3-2
FIGURE 3	Gating Uncertainty	3-4
FIGURE 4	Gating Error: Rate vs Period Measurement	3-4
FIGURE 5	Noise on Input Signal	3-5
FIGURE 6	Trigger Error Due to Noise	3-6
FIGURE 7	Self Test Measurement	3-6
FIGURE 8	Rate (Frequency) Measurement	3-7
FIGURE 9	Time Interval Measurement	3-8
FIGURE 10	Period Measurement	3-8
FIGURE 11	Ratio Measurement	3-8
FIGURE 12	Basic Counter, SD 7014	4-6
FIGURE 13	Count Gate Control	5-5
FIGURE 14	SD 7014 Timing Diagram	5-7

TABLE OF CONTENTS (cont)

PAGE

LIST OF TABLES

Table 1 Recommended Test Equipment 1-4
Table 2 Total Error 3-6
Table 3 Test Results 3-6
Table 4 Function Switch Rate Position 3-7

CHAPTER 1

GENERAL DESCRIPTION

1.1 BASIC FUNCTIONS

The SD 7014 is a solid-state instrument capable of performing a wide range of counting and timing measurements. It has six basic measuring modes: Rate (frequency), Count (totalize), Hold, Time Interval (Start-Stop), Period (single or multiple), and Ratio (f_1/f_2).

1.2 STANDARD FEATURES

Simple, reliable, accurate operation and easy maintenance are hallmarks of the SD 7014. Its circuitry, completely solid state, is constructed on printed circuit plug-in modules. Test points are color coded and functionally placed for troubleshooting. The seven digit in-line readout displays an answer continuously until the end of the next measurement cycle.

Automatic decimal and units-of-measure indications are provided for all rate and period measurements. The time base crystal oscillator has a stability of better than 2 parts in 10^6/month. The oscillator's stability combined with the variable display time of the seven digit readout results in excellent readability and accuracy.

1.3 APPLICATIONS

The SD 7014 can be employed in the measurement, analysis, and counting of both periodic and random signal pulses of arbitrary waveshape within the rated frequency characteristics of the instrument. Because it operates directly from voltage inputs, it is an invaluable tool for the designing, manufacturing, and testing of instruments and circuits having an electrical output related to time interval, frequency, and number of occurances. It is commonly used for the design and calibration of transmitting and receiving equipment, tuned circuits, and crystals. Other common applications are calibration of resolvers and synchros, and the measurement of gain-phase characteristics of closed loop servo systems.

When employed with suitable input transducers (photo cells, magnetic pickups, or switches), the SD 7014 becomes equally valuable for measuring physical events with respect to time; for example: Speed of rotation, flow rate, or production unit counting.

1.4 OPTIONAL FEATURES

A variety of optional features are available to adapt the SD 7014 to many custom requirements. Options include 1-2-4-8 BCD Digital output (suitable for driving digital printers), a heated crystal, extra readout tubes (to nine maximum), and a selection of high-stability oscillators. See Chapter 1.5, Specifications, for more detailed optional features information.

1.5 SPECIFICATIONS

FREQUENCY MEASUREMENTS

Range: 0 to 20 MHz (DC input); 10 Hz to 20 MHz (AC input).

Input: 10 mV sensitivity; 1 MΩ/50 pF. 10 Hz to 12.5 MHz and increasing to 60 MV at 20 MC

Gate Time: .01, 0.1, 1, 10 seconds

Accuracy: ±1 count ± time-base accuracy

Reads In: kHz or MHz with positioned decimal point

Self Check: Counts 1 MHz for gate time selected.

Readout: 7 digits in-line

PERIOD AVERAGE MEASUREMENTS

Range: Single or Multiple Period. 0 to 5 MHz

Periods Averaged: 1 to 10^5 periods in decade steps

Accuracy: ±1 count ± time-base accuracy ± trigger error. Trigger error is less than ±0.3% of one period ÷ periods averaged for signals with 40 db or better signal-to-noise ratio

Sensitivity: 100 mV from DC to 1 kHz; 10 mV from 1 kHz to 5 MHz

Frequency Counted: 1 MHz

Reads In: µS with positioned decimal point

TIME INTERVAL MEASUREMENTS

Range: 10 µS to 10 sec

Inputs (or rear panel): Contact closure or saturated NPN transistor to ground. Signal duration: $\geq$ 1 µS. Current sinking: $\geq$ 2 mA. The START signal must end before the STOP signal begins. Time from STOP to next START: not less than 30 ms for external reset, or not less than 30 ms + sample time for internal reset

Frequency Counted: 1 MHz internal time base or external frequency standard.

Readout: µS with positioned decimal point.

RATIO MEASUREMENT

Displays: (f_1/f_2) X period multiplier; Multipliers: 1, 10, 10^2, 10^3, 10^4, 10^5

Range, Sensitivity: f_1: 1 kHz to 2 MHz into external time-base BNC connector, 1V rms minimum into 1000Ω f_2: 0 to 5 MHz. 10 mV sensitivity except 100 mV below 1 kHz.

Accuracy: ±1 count of f_1 ± trigger error of f_2. See Trigger Error note under Period Average Measurements (above).

Readout (legend and decimal): Indicating but not applicable

TIME BASE

Crystal Frequency: 1 MHz

Stability:

Aging Rate: Better than 2 parts in 10^6/ month.

Temperature: Less than 1 part in 10^5 from +15°C to +35°C; less than 3 parts in 10^5 from 0°C to +50°C.

Line Voltage: Less than 1 part in 10^6 for ±10% change.

Output Frequency: 1 MHz, 3 V p-p minimum open circuit; Source impedance 2000Ω maximum.

External Input: 1 kHz to 2 MHz sine wave, 1 V rms into 1000Ω 10 V rms maximum

GENERAL

Registration: 7 digits in-line with options to 9.

Display Storage: Provides a continuous display of the most recent measurement. Switch on rear panel overrides storage.

Sample Rate: 0.2 s to 5 s independent of gate time, or HOLD until manual reset.

Reset: Manual pushbutton or remote contact closure, or saturated NPN transistor to ground through rear-panel BNC connector.

Operating Temperature Range: 0°C to +50°C

Signal Sensitivity: Front and Rear inputs, 10 mV rms; except 100 mV rms max. (0 to 1 kHz) for period, ratio measurements. 60 mV for 20 MHz frequency measurements

Coupling: AC or DC, switch selectable

Attenuation: Step attenuator with factors of 1, 10, and 100

Input Level: ±1 volt times attenuation factor. A "preset" position of the Trigger Level control automatically centers trigger level at 0 volt.

Overload Without Damage: 75 V peak on X1, 200 V peak on X10, 300V peak on X100 attenuator setting

Dimensions: 5 1/4" high by 10 1/4" wide by 15" deep

Weight: 13 pounds net; 15 pounds shipping

Power: 115 V/220 V ±10%, 50 to 400 Hz

OPTIONAL FEATURES

Designation:

B High Stability Oscillator
Aging rate less than 1 part in 10^9 per 24 hours.

B3 Medium-Stability Oscillator
Aging rate less than 3 parts in 10^9 per 24 hours.

B4 Super-High-Stability Oscillator
Aging rate less than 5 parts in 10^{10} per 24 hours

D3 1-2-4-8 BCD Digital Output
1 = +5V nominal (open circuit); 0= 0V (nominal). Source impedance 5.7 KΩ. Print command: step from 0V to +5V. Inhibit: 0V inhibits, +10 V operates.

E Addition of extra readout digits (to 9 maximum)

XTL Heated Crystal
Aging rate less than 3 parts in 10^7 per week.

N Rack Mounts
Easily installed and removed, are factory supplied ready to adapt the SD 7014 to standard 19 inch rack configurations.

1.6 RECOMMENDED TEST EQUIPMENT

Table 1 lists the equipment and publications required to troubleshoot, operate, and calibrate the SD 7014. Substitution of equivalent test equipment for those listed below is acceptable.

TABLE 1

RECOMMENDED TEST EQUIPMENT

QUANTITY	DESCRIPTION	NOMENCLATURE	REQUIRED USE
	Oscilloscope	Tektronix Model 581	Troubleshooting and Calibration
	Plug-in Unit	Tektronix Model 82	Troubleshooting and Calibration
	One MHz Frequency Standard	1 part in 10^{10} short term stability *	Troubleshooting and Calibration
1	Instruction Manual (SD 7014)		Operating instructions for SD 7014
1	EIR Voltmeter		Troubleshooting and Calibration
1	Test Oscillator	HP 651-B	Troubleshooting
1	Signal Generator	HP 675-A	Troubleshooting and Calibration
1	Coaxial Jumper cable	50 ohms	Troubleshooting and Calibration

* 1 part in 10^7 short term is acceptable for the standard SD 7014 oscillator

1.7 PREPARATION FOR RESHIPMENT

Should reshipment become necessary, contact the nearest Systron-Donner field office for shipping instructions. If possible, use the original packaging materials or repack in accordance with MIL-P-116 and MIL-E-1755E. Systron-Donner field offices can provide materials similar to those used for original factory packaging. All correspondence should refer to the full nomenclature and serial number of the instrument involved.

CHAPTER 2

INSTALLATION

2.1 INSTALLATION

The SD 7014 has no special installation requirements. It is good practice, however, to make sure the 115V/230V LINE switch setting and the ac power source are the same, to install the unit as far from heat-producing equipment as possible, and to avoid exceeding the operational limits of the counter.

2.2 INSPECTION AND ADJUSTMENT

As soon as the instrument is received, verify that it is intact and as ordered. If shipping damage of any nature is found, refer to the Warranty (inside back cover) and to Paragraph 1.7 for repackaging and shipping instructions.

The overall functional test described in Paragraph 4.5 should be performed as soon as the instrument is received. All internal adjustments are factory set, so the instrument should be ready for use as received. Should the instrument fail to function properly or fail to meet specifications, contact your Systron-Donner representative.

CHAPTER 3

OPERATION

3.1 PREPARATION FOR USE

Make sure POWER ON/OFF switch is OFF. Determine that the 115v/230v LINE VOLTAGE switch is in the correct position. Connect the SD 7014 to the ac power source.

3.2 CONTROLS, INDICATORS, AND CONNECTORS

Figures 1 and 2 show the location of all controls, indicators, and connectors. The following paragraphs present their functional descriptions:

FRONT PANEL

3.2.1 RECYCLE RATE CONTROL

Turns power on and off and sets counter display time from 0.2 to 5 seconds. When positioned at infinity, the counter displays the last measurement indefinately or until the RESET pushbutton is depressed.

3.2.2 GATE INDICATOR

lights for the duration of the measurement interval (gate). It provides a positive instrument-is-counting indication, especially when the STORAGE ON display mode is selected.

3.2.3 FUNCTION SWITCH

1) PERIOD -- measures time of one to 10^5 periods (in decade steps) of input waveform.

2) RATE -- measures frequency by counting each input cycle during a selected time base period, 10 millisecs to 10 seconds in decade steps. This switch also controls the automatic decimal point and units-of-measure indicators.

3) COUNT -- totalizes the numver of cycles applied to the INPUT BNC.

4) HOLD -- an extension of the COUNT mode. When HOLD is initiated, the COUNT function ceases and the counter retains and displays the accumulated count. When the COUNT mode is again selected, the counter continues to totalize from the point at which HOLD was initiated.

3.2.4 READOUT INDICATORS

Consist of seven (options to nine) numerical indicator tubes and an automatically positioned decimal point.

3.2.5 INPUT ATTENUATOR

Selects attenuation networks which will decrease input signal amplitude by a factor of 10 or a factor of 100. The TEST position provides a convenient means of self-testing the counting circuits.

3.2.6 TRIGGER LEVEL CONTROL

Is used to select a dc voltage level which will produce consistent triggering of the counting circuits. The PRESET position centers the trigger level, automatically, at zero cross-over.

3.2.7 ANNUNCIATOR ASSEMBLY

Indicates units-of-measure in kHz, MHz, µs, and OS (off scale).

3.2.8 AC-DC SWITCH

Permits ac or dc coupling of the input signal. The AC position, via a .1 µfd capacitor in series with the INPUT connectors, ac couples the input signal to the counter's input amplifier.

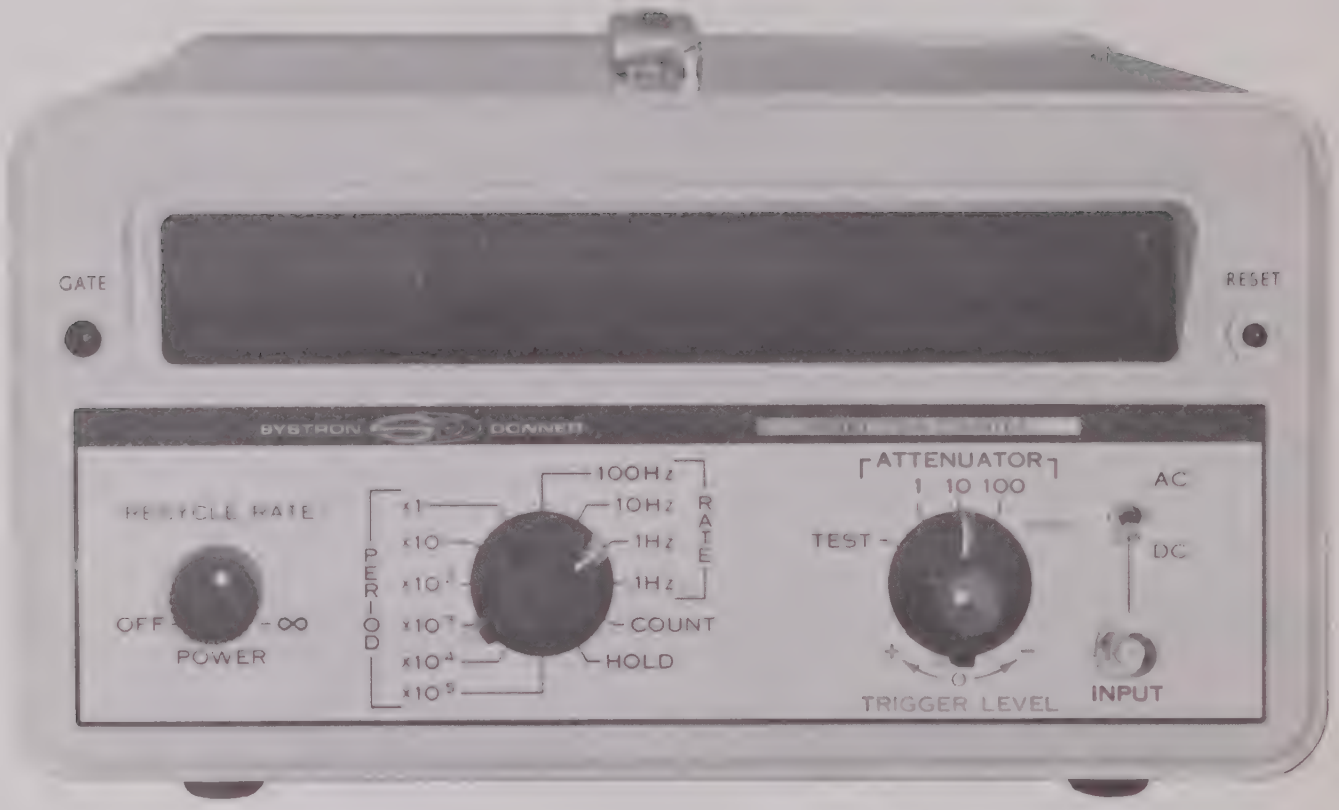

FIGURE 1 SD 7014 Front Panel

FIGURE 2 Rear Panel

YOUNG MAN: "Oh, at last I've found you Sir! Here is the most recent revision to your Systron-Donner Instruction Manual. It's chock-full of new information. Why, there are five changes in the Spare Parts List alone! I would have hastened to you with it sooner, Sir, but I had no idea of your name or department number or mailing address. Those nice gentlemen in the club car said I might find you here."

SEATED GENTLEMAN: "Young man, I have no idea what you are talking about. And what were you doing in the club car?"

See our problem? Fill out this form and mail it today. Thanks.

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3.2.9 INPUT CONNECTOR
Accepts an input signal (front panel).

3.2.10 RESET PUSHBUTTON
Manually resets the counter to zero. When this switch is pushed, the counter first resets to zero and then begins its next counting cycle.

REAR PANEL

3.2.11 115v/230v LINE SWITCH
Adapts the SD 7014 to either a 115V ac or 230 V ac primary power source. *Do not apply 230 ac to the unit with this switch in the 115V position.*

3.2.12 STORAGE ON/OFF SWITCH
Allows the SD 7014 to hold and display the last measurement taken until the next measurement-interval (ON position). In the OFF position, storage is defeated and the display constantly updates itself.

3.2.13 INPUT CONNECTOR
Accepts an input signal (rear panel).

3.2.14 RESET CONNECTOR
Allows the counter to be reset remotely by a contact closure to ground. See "Reset", Paragraph 1.5.

3.2.15 BCD OUTPUT CONNECTOR (Optional)
Provides the display-readout information in binary coded decimal form for use with peripheral equipment.

3.2.16 NORM/TIM SWITCH
Permits time interval measurements to be made by the counter (TIM position). The TIM position, essentially, instructs the counter to count 1 MHz for a certain time interval, determined by the two signals applied to the START BNC and the STOP BNC. See Paragraph 1.5, under Time Interval Measurements. All counter functions, other than TIM, are accomplished with the NORM/TIM switch in the NORM position.

3.2.17 INT-EXT ONE MHz SWITCH
Supplies a 1 MHz counter output signal, (derived from the internal time base) to the 1 MHz BNC (INT position) or accepts an external 1 MHz time base input at 1 MHz BNC (EXT position).

3.2.18 FREQ. ADJ. (Coarse, Fine)
Are used to adjust the internal time base oscillator frequency to 1 MHz. See the Maintenance-Calibration Chapter 4 for more detailed information.

3.3 ACCURACY OF MEASUREMENT
If the SD 7014 is to be used to make critical measurements, several factors which may cause errors in counter measurements must be considered. The following paragraphs will illustrate most types of counter errors and present practical solutions to problems created by such errors.

3.3.1 Oscillator Stability
Digital frequency measurements are subject to several types of errors. One of the most significant is inaccuracy of the timing interval, as determined by the stability of the crystal-controlled oscillator. The three commonest causes of oscillator instability are the oscillator's inherent aging rate (usually 1 part in 10^6 to 5 parts in 10^{10}), operation temperature variations, and line (supply) voltage fluctuations.

Errors due to oscillator instability may be reduced by the following techniques:

1) By leaving the counter on all the time. The aging rate of an oscillator is greatest when it is first turned on. As an example, the high stability oscillator available for Systron-Donner counters has an aging rate of 1 part in 10^9/day after 30

hours continuous operation. After 60 days continuous operation, the aging rate improves to 3 or 4 parts in 10^{10}/day.

2) By frequent calibration with a frequency standard (periodic comparison against a primary frequency standard allows the oscillator to be corrected for drift.

3) By substitution of an external oscillator in place of the standard internal oscillator. If an oscillator with better stability than that of the counter is readily available, it should be used.

3.3.2 Gating Error

Gating error is responsible for a possible error of ±1 count (in the least significant digit of the display) in almost all types of counter measurements. This error is possible because the incoming signal passing through the count gate is not synchronized with the time base pulses which control the gate.

As demonstrated in Figure 3, the first or last cycle of the input signal may or may not pass through the gate during the selected measurement interval.

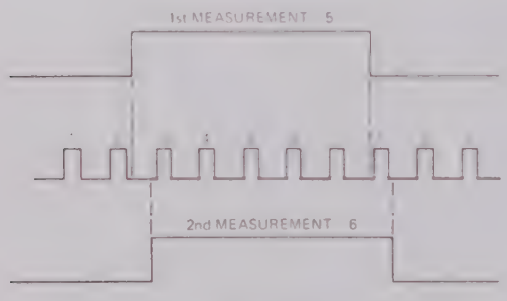


FIGURE 3 GATING UNCERTAINTY

For high frequency measurements, the ±1 count gating error is insignificant compared to the total count. At low frequencies, however, the error may become important. For this reason, the period mode of measurement is normally used to obtain greater accuracy. Figure 4 shows which type of measurement will yield the lowest gating error.

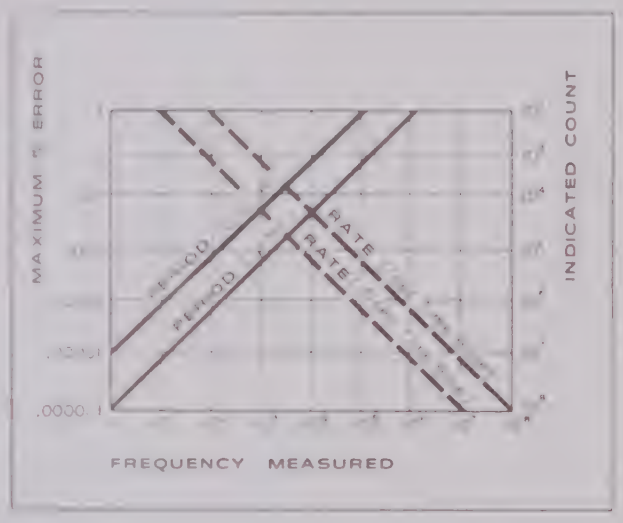


FIGURE 4 GATING ERROR: RATE vs PERIOD MEASUREMENT

Gating error can be reduced by a factor of 10 by extending the interval of measurement (Period x 10, etc.). The total count is multiplied by ten but the gating error remains ±1 count.

For example, if a 10 kHz is measured over a 0.1 second time base, the count indicated would be 1000 ±1 and the percentage of error would be ±0.1%. Measured over a 1 second time base, the count indicated would be 10,000 ±1 and the percentage or error would be reduced to ±0.01%.

3.3.3 Count Error Produced by Noise in Frequency Measurements

Noise superimposed on the input waveform may cause spurious count pulses to appear at the output of the input amplifier, which might then be counted, each time the input signal crosses and re-crosses the selected amplifier trigger voltage level, as shown in Figure 5. Since an input signal cycle must usually have amplitude of at least 0.2 to 0.3 volts p-p to cause triggering, spurious counts can be eliminated by attenuating the total "input plus noise" signal to a suitable amplitude.

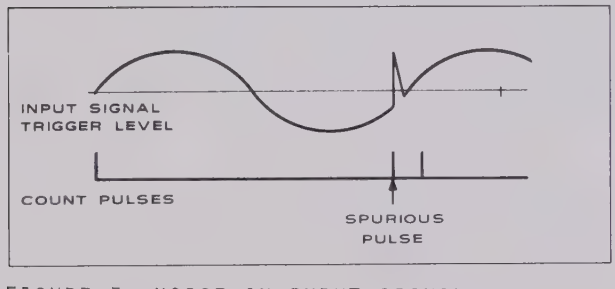


FIGURE 5 NOISE ON INPUT SIGNAL

It is important to have both attenuator and trigger level controls set properly when measuring signals under marginal conditions of noise.

3.3.4 Loading Error

One frequently overlooked and generally not significant error may occur if the connection of the instrument to the external signal causes a frequency or amplitude shift of the external signal.

This error will only be noticed with signal sources of relatively high impedance (high frequency signals) in comparison to the input impedance and frequency rating of the counter.

For signals of sufficient amplitude, the loading error can be reduced by placing either a small coupling capacitor or a larger resistor in series with the input signal. The isolating component should be located at the signal source so that it will also isolate the cable capacity.

The loading caused by connecting the input impedance to the start and stop channels of a specific signal source, can be calculated to determine if the source of error is significant. For example, if a counter with a 10 megohm input impedance is used with a signal source having a 10,000 ohm output impedance, the effective value of this resistor is changed by approximately 0.1%. This would be equivalent to shifting the phase of a 60 cycle signal by approximately 0.23 degrees.

3.3.5 TRIGGER ERROR

In addition to gating error, oscillator drift and loading errors, the Period and related Time Interval Measurements are subject to a trigger time error caused by noise on the input signal.

The total signal may be considered as an ideal noise free signal with a superimposed noise signal. The noise added to the ideal signal may trigger the channel before or after the selected instant for triggering. The maximum error in time for a given p-p noise voltage (Vn) and the slope of the ideal signal at the trigger level is:

$$t\ (\text{sec}) = \frac{Vn \quad (\text{Volts})}{\text{Slope (Volts/sec)}}$$

The maximum percent error is

$$\text{Max \% error} = \frac{t \times 100\ (\text{sec})}{T\ (\text{sec})}$$

For a sine wave triggering at its zero cross-over point:

$$\text{Max \% error} \pm \frac{Vn \times 100\ (\text{volts})}{Vs \quad (\text{volts})}$$

This error effectively lengthens or shortens the period measurement as depicted in Figure 6. The percentage of error is given by the formula 100/T, where T is the actual period and is the trigger error (in seconds).

From the foregoing discussion, it can be seen that as the amplitude of signal voltage is increased, the percentage of error is diminished. In addition, if the trigger level is set at the center of the steepest slope of the waveform, the maximum error will be reduced.

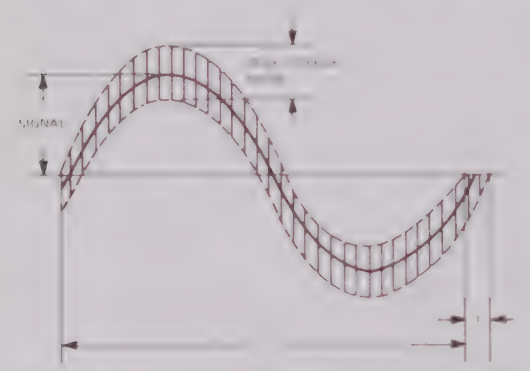


FIGURE 6 TRIGGER ERROR DUE TO NOISE

Another way to reduce trigger error is to measure multiple periods of the gating signal. Since this error occurs only with the first and last pulses of the measuring interval, the trigger error will be reduced by a factor of 1/M if the measurement is extended for M periods.

The various errors add up in the following manner (as depicted in Table 2) to form the total error for each of the functions.

TABLE 2 TOTAL ERROR

FUNCTION	ERRORS PRESENT
RATE	GATING + DRIFT + LOADING
PERIOD & TIME	GATING + DRIFT + TRIGGER + LOADING
RATIO & GATE	GATING + TRIGGER + LOADING

3.4 EQUIPMENT OPERATION

The following paragraphs explain the functional operation of the counter. All of the operating procedures have a "counter ON and warmed up" prerequisite.

3.4.1 Test Function

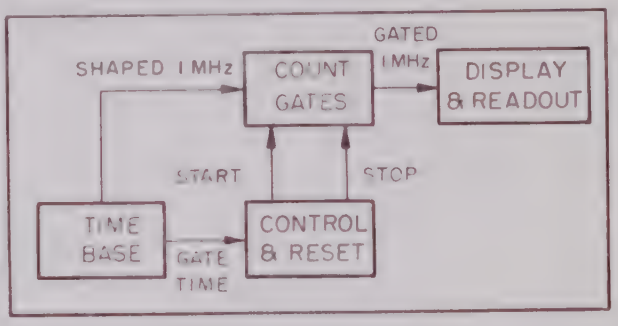


FIGURE 7 SELF TEST MEASUREMENT

1) Place the ATTENUATOR switch in the TEST position.

2) Turn RECYCLE RATE control fully counter-clockwise, but not OFF (minimum display time.

3) Turn STORAGE switch ON.

4) Place INT-EXT switch in INT (internal) position.

5) Beginning with 10^{-2} (100 Hz), place the FUNCTION switch in each of its "time base" (RATE) positions -- agreement with Table 3 signifys fully operational counting circuitry.

TABLE 3

Function Switch Position	Correct Indication
100 Hz (10 ms time base)	001.0000 MHz
10 Hz (100 ms time base)	01.00000 MHz
1.0 Hz (1 sec time base)	1000.000 kHz
0.1 Hz (10 sec time base)	000.0000 kHz*
0.1 Hz (8 digit readout)	1000.0000 kHz
0.1 Hz (9 digit readout)	01000.0000 kHz

* OS Lamp Lights

3.4.2 Frequency (RATE) Measurements

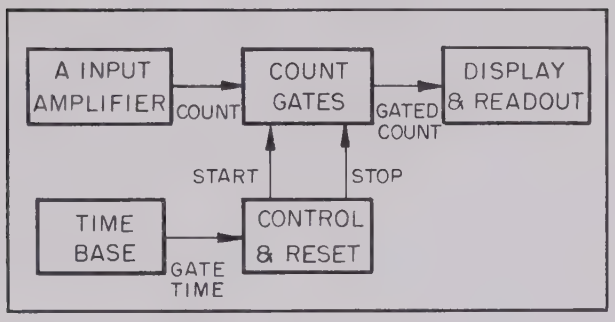


FIGURE 8 RATE (FREQUENCY) MEASUREMENT

1) Set the FUNCTION switch to the RATE position which will result in the desired resolution. See Table 4.

TABLE 4

RESOLUTION	10 ms	100 ms.	1 sec.	10 sec.
	100 Hz	10 Hz	1 Hz	0.1 Hz.

FUNCTION SWITCH RATE POSITION →

2) On the rear panel, set the INT-EXT switch to INT. Set the STORAGE switch as desired.

3) If the amplitude of the frequency to be measured is known, set the ATTENUATOR switch as follows: If the input amplitude is between 0.1V and 1.0V p-p, set range to 10; if above 1.0V p-p, set range to 100.

CAUTION: the counter will not operate properly with input signals above 150V peak-to-peak and signals greater than 250V p-p will damage the instrument.

If the amplitude of the signal to be measured is unknown, place the ATTENUATOR switch to 100. Perform Step 4, then decrease the attenuation range until correct operation is observed.

4) Apply the signal to be measured to either INPUT connector.

5) Set the AC-DC switch as desired.

6) Rotate the TRIGGER LEVEL control until a stable count is observed on the indicators. If no count is observed, place the ATTENUATOR switch in the next lower range.

NOTE: It is normal for the less significant digits to fluctuate. Most input signals will have enough instability to cause some variation.

3.4.3 Count (Totalize) Measurements

1) Set the ATTENUATOR switch as in Paragraph 3.4.2, step 3.

2) Apply signal to be counted to either INPUT connector.

3) Place the AC-DC switch as desired.

4) Put the FUNCTION switch to COUNT.

5) Rotate the TRIGGER LEVEL control until the indicators begin to cycle (the storage feature is automatically defeated in COUNT).

6) If the count is to begin at a particular point in time, place the FUNCTION switch in HOLD (which stops the count), depress the RESET momentary pushbutton (which sets the indicators to zero), and then return the FUNCTION switch to COUNT at the desired "start" time.

3.4.4 Hold Function

1) Set the FUNCTION switch to HOLD -- the count will stop and remain displayed. The count may be set to zero by initiating reset, either remotely or with the RESET pushbutton.

2) To resume the count or start a new count, return the FUNCTION switch to COUNT.

3.4.5 Time Interval Measurements

1) Set the FUNCTION switch to the COUNT position.

2) Place the NORM/TIM switch to the

TIM position.

3) Apply acceptable start and stop signals (see Paragraph 1.5, the Time Interval Measurements Inputs section) to the START and STOP input BNC connectors.

4) Be sure the NORM/TIM switch is in the NORM position for all functions except time interval measurement.

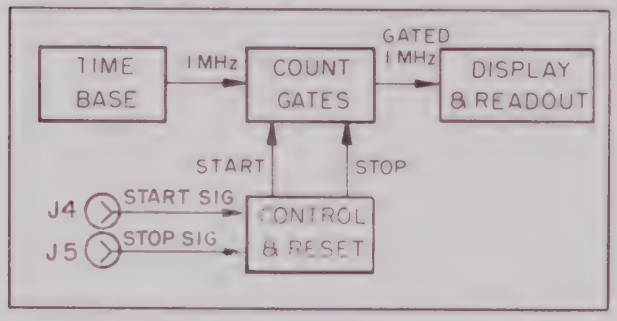


FIGURE 9 TIME INTERVAL MEASUREMENT

3.4.6 Period Measurements

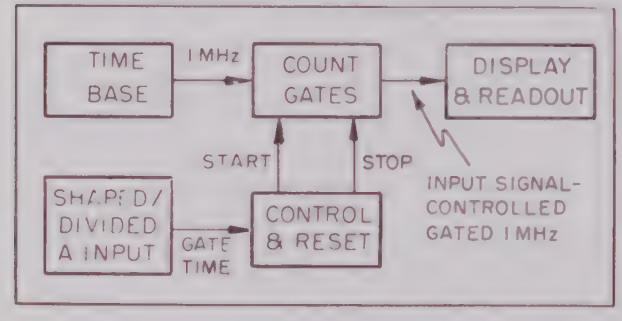


FIGURE 10 PERIOD MEASUREMENT

1) Set the FUNCTION switch to the desired PERIOD position.

2) Set the ATTENUATOR switch as in Paragraph 3.4.2, Step 3.

3) Set the AC-DC switch as desired.

4) Apply the signal to be measured to either INPUT connector.

5) Rotate the TRIGGER LEVEL control until a stable indication is displayed. If no indication is displayed, select the next lower ATTENUATOR switch range position. Should the indication be unstable, check the frequency amplitude, and stability of the input signal.

3.4.7 Ratio Measurements

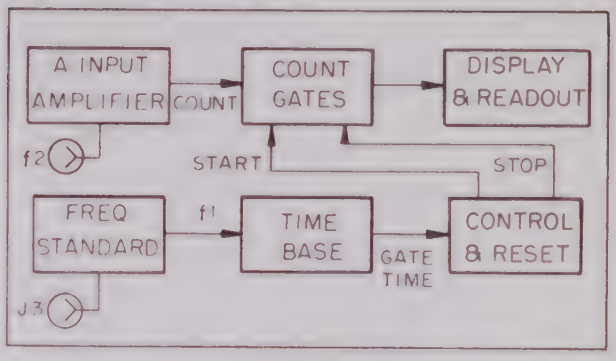


FIGURE 11 RATIO MEASUREMENT

1) Set FUNCTION switch to the PERIOD position which provides the desired resolution.

2) Place the INT-EXT switch to EXT.

3) Apply the f_1 signal input, 1 kHz to 2 MHz, to the 1 MHz BNC connector.

4) Apply the f_2 signal input, 0 to 5 MHz, to either INPUT connector.

5) Adjust TRIGGER LEVEL control for most stable indication. The counter indication will be the ratio between f_1 and f_2 times the PERIOD position multiplier.

CHAPTER 4

MAINTENANCE/CALIBRATION

4.1 FACTORY SERVICE

Whenever the instrument requires service, the nearest Systron-Donner representative should be contacted. He can provide field service or arrange factory returns when necessary. Address all inquires on operation or application to your nearest sales representative, or to Sales Manager, Systron-Donner Corporation, 888 Galindo Street, Concord, California, 94520. Specify both model and complete serial number in all correspondence.

4.2 ROUTINE MAINTENANCE

A regular program for routine maintenance and inspection every five to six months is recommended for this counter (the oscillator may require calibration at more frequent intervals). As part of these regular procedures, the instrument should be checked in the following manner;

a) Disconnect ac power and remove the top and bottom covers by removing the rear panel retaining frame (six screws).

b) Make a thorough inspection of all wiring and cables. Check for frayed, loose, or burned wires.

c) Check for physical integrity of all components. Look for burning or cracking, loose solder connections, leakage of insulation compounds, and general physical damage. If a printed circuit board contains integrated circuit packages, ensure that all packages are firmly mounted. Never unnecessarily remove and replace a package.

d) Check all front panel switches and controls for loose or broken terminals, loose or sticking shafts, etc.

e) If the internal panel surfaces and components have an excessive amount of dust deposited on them, use a soft brush and low pressure stream of air to remove the foreign material.

CAUTION

Do not clean PC boards or small internal components with a stiff brush or solvents, since damage to the circuits may result. A high-powered vacuum cleaner device should not be used on small internal components.

f) Wipe the external surfaces of the instrument with a soft damp cloth to remove dirt, fingerprints, and other foreign material.

g) Replace the top and bottom covers and reconnect ac power. Perform the Operational Test Procedure (Paragraph 4.5). If performance does not match or exceed the specifications listed in Chapter I of this manual, perform the Calibration Procedure (Paragraph 4.6).

4.3 PRINTED-CIRCUIT BOARD REPAIR

To remove a part on a printed circuit board, cut the leads of the part near the lead holes. Using a low power (50 watts or less) soldering iron, apply heat sparingly to each cut lead. As soon as the solder melts, slip the lead from the hole and clean the hole with a toothpick. Clean the board surfaces with isoprophyl alcohol. Form the tinned leads of the replacement part and insert in cleaned holes, trimming leads to ex-

tend 1/16 inch beyond the back surface of the board. Only 63-37 solder with a maximum diameter of 1/16 inch should be used. Solder the leads to the board and use a hemostat, long-nosed pliers, or other heat sink on all leads of all semiconductor devices and quarter-watt resistors. Allow the soldered junction to cool before removing the heat sink.

4.4 PARTS LOCATION

Printed circuit board outline drawings, with each part located upon the drawing, are located in Chapter 6.

4.5 OPERATIONAL TEST PROCEDURE

The following procedure will establish that the SD 7014 20 MHz Counter circuits are functioning correctly. It is written with the assumption that the SD 7014 under test is equipped with seven readout digits and the standard time base oscillator. Correct indications for other configurations of the SD 7014 (optional equipment), if included, are shown in Chapter 7 of this manual.

STEP	ACTION	INDICATION
1	a) Connect SD 7014 to ac power; make sure LINE switch agrees with power source	
	b) INT-EXT switch to INT. NORM/TIM switch to NORM	
	c) TRIGGER LEVEL control to PRESET	
	d) STORAGE switch to ON	
	e) ATTENUATOR switch to TEST	
	f) FUNCTION switch to PERIOD X 1	
	g) POWER ON/OFF and RECYCLE RATE control to ON and midrange	Display illuminates, reads 0000001 ±1 μ sec. A 1 MHz 3 V p-p signal is available at the 1 MHz OUT connector.
	h) FUNCTION switch to X10	Display reads 000001.0 ±0.1 μ sec.
	i) FUNCTION switch to $X10^2$	Display reads 00001.00 ±.01 μ sec.
	j) FUNCTION switch to $X10^3$	Display reads 0001.000 ±.001 μ sec.
	k) FUNCTION switch to $X10^4$	Display reads 001.0000 ±.0001 μ sec.
	l) FUNCTION switch to $X10^5$	Display reads 01.00000 ±.00001 μ sec.
2	a) FUNCTION switch to COUNT	Display totalizes at a 1 MHz rate. The GATE lamp is constantly on. No decimal point or legend information is displayed.

STEP	ACTION	INDICATION
	b) FUNCTION switch to HOLD	Display holds count indefinately. GATE lamp is constantly off.
	c) FUNCTION switch to COUNT	Display beging to totalize again from point at which HOLD was initiated.
3	a) FUNCTION switch to 1 Hz	Display reads 000.0000 ±.0001 kHz. Off-scale (OS) lamp illuminates.
	b) FUNCTION switch to 1 Hz	Display reads 1000.000 ±.001 kHz. OS lamp goes out.
	c) FUNCTION switch to 10 Hz	Display reads 01.00000 ±.00001 MHz.
	d) FUNCTION switch to 100 Hz	Display reads 001.0000 ±.001 MHz.
4	a) RECYCLE RATE full CCW but not to OFF	Display time should be 0.2 seconds or less
	b) RECYCLE RATE full CW but not to ∞	Display time should be 5 sec. or greater
	c) Depress RESET button several times	Counter should reset instantly each time (GATE lamp should flicker).
	d) RECYCLE RATE to ∞	Counter no longer resets automatically at end-of-measurement. It will reset manually however.
5	a) RECYCLE RATE full CW (not ∞)	Display reads as in 3d above
	b) STORAGE switch to OFF	Counter resets to 0, then counts to 3d.
	c) Return STORAGE switch to ON	
6	a) ATTENUATOR to 1	
	b) Place INT-EXT switch to EXT	
	c) Apply 1 MHz frequency standard, 1 V rms, to 1 MHz connector	
	d) Apply 5 MHz, 100 MV, signal to INPUT connector.	
	e) FUNCTION switch to PERIOD x 10^2	Display reads 00005.00 μ sec, but legend and decimal point are not applicable in RATIO
	f) Remove inputs and return INT-EXT switch to INT	Display reads 00000.00 μ sec.
7	a) FUNCTION switch to COUNT	Display reads 0000000.

STEP	ACTION	INDICATION
	b) Vary TRIGGER LEVEL about zero, plus to minus and minus to plus	Display should register a count each time the control passes through zero.
	c) TRIGGER LEVEL to PRESET	
8	a) FUNCTION switch to PERIOD X1	
	b) ATTENUATOR switch to 10	
	c) STORAGE ON/OFF to OFF	
	d) Connect 1 MHz OUT jack to A INPUT connector	
	e) Vary the position of the FUNCTION switch from PERIOD X1 to PERIOD X10^5. Check each numerical indicator tube for 0 through 9 sequencing -- numbers should be clear and distinct	
	f) Remove test jumper, turn ATTENUATOR switch to 1, and flip STORAGE switch to ON.	
9	a) FUNCTION switch to 10 Hz	
	b) Apply 60 MV, 20 MHz signal to either A INPUT	
	c) Adjust TRIGGER LEVEL control for correct indication	Display should read 20.00000 ±.00001 MHz
	d) Remove 20 MHz input and apply a 10 MV, 12.4 MHz signal to A INPUT connector	
	e) Readjust TRIGGER LEVEL control for correct indication	Display should read 12.40000 ±.00001 MHz
	f) Remove 12.4 MHz input signal	
10	a) FUNCTION switch to COUNT b) NORM/TIM switch to TIM	
	c) RECYCLE RATE to ∞	
	d) Ground rear panel START BNC	Counter should begin counting at a 1 MHz rate.
	e) Remove START BNC ground	

STEP	ACTION	INDICATION
	f) Ground rear panel STOP BNC	Counter stops counting and displays in μ sec. the time between the START BNC going to ground and the STOP BNC going to ground.
	g) Remove STOP BNC ground and return RECYCLE RATE to midrange	
	h) Return NORM/TIM switch to NORM	SD 7014 is operating correctly

4.6 CALIBRATION PROCEDURE

Place RECYCLE RATE switch to OFF. Remove the ac power source. Remove counter's top and bottom covers per Paragraph 4.2 a. Make sure the LINE switch and ac power source are in agreement.

Reapply ac power source. Turn RECYCLE RATE switch ON. Perform steps in their listed sequence since some adjustments interact.

ADJUSTMENT	PROCEDURE
R116 -- Positive 5V regulator (Power Supply Board)	Monitor the +5V test point on the Power Supply Board with the voltmeter. Adjust R116 for +5V ±150 mV.
	With the oscilloscope, monitor the +5V test point for ripple of 50 mV maximum.
R127 -- Negative 5V regulator (Power Supply Board)	Monitor the -5V test point on the Power Supply Board with the voltmeter. Adjust R127 for -5V ±150 mV.
	With the oscilloscope, check the -5V test point for ripple of 50 mV maximum.
C13 -- Coarse Frequency Adjustment (Rear Panel)	With the INT-EXT switch in INT, correct the oscilloscope (triggered by the frequency standard) to the 1 MHz OUT jack on the rear panel. Adjust C13 for a near stationary waveform.
C2 -- Fine Frequency Adjustment (Rear Panel)	With scope still connected, adjust C2 for a stable trace on the scope. Disconnect scope (B option oscillator only).

ADJUSTMENT	PROCEDURE
R3 and R5 -- Amplifier Balance and Preset Potentiometers (Amplifier and Shaper Board).	Place TRIGGER LEVEL control to PRESET and the ATTENUATOR switch to 1. Place FUNCTION switch to .1 Hz. Set R5 to midrange. With the voltmeter, monitor the emitter of Q3 and adjust R3 for a reading of approximately 1 volt. Apply a 30 mv, 100 Hz. signal to the A INPUT and adjust R3 for proper display indication. Apply a 10 mv, 100 Hz signal to the A INPUT connector. Adjust R5 for proper display indication. Start decreasing the input signal amplitude in small increments. Readjust R5 each time for correct display indication until maximum sensitivity is achieved.

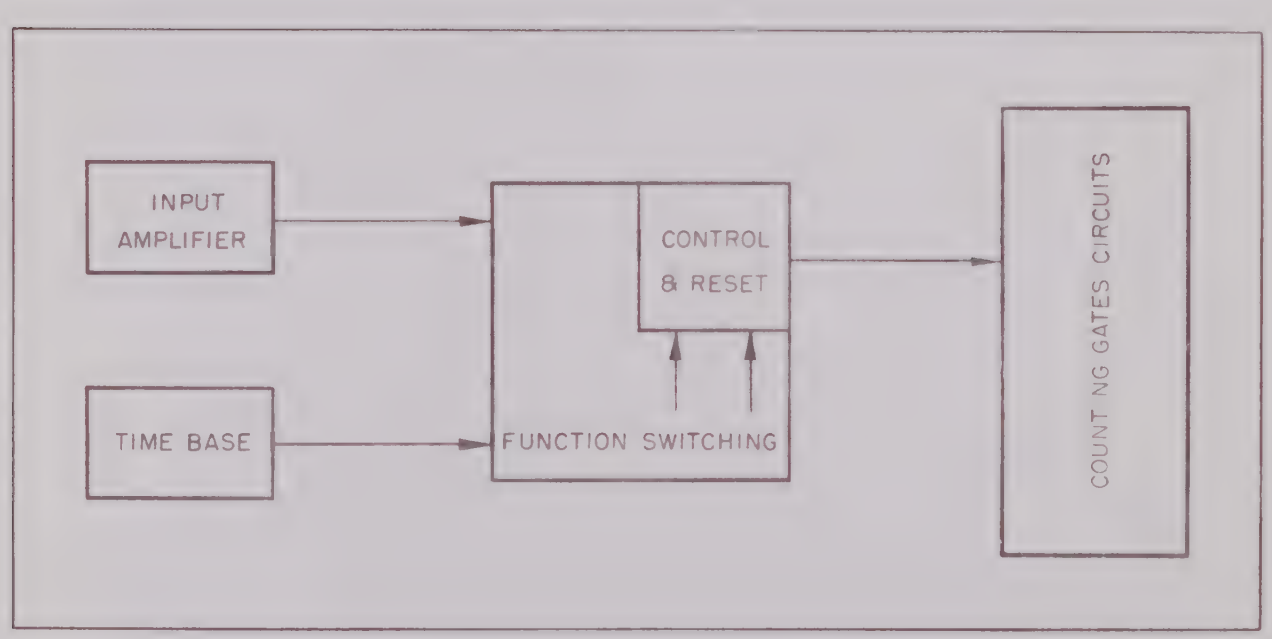


FIGURE 12 BASIC COUNTER, SD 7014

CHAPTER 5
THEORY OF OPERATION

5.1 GENERAL THEORY OF OPERATION (Figure 12).

The counter is composed of four basic elements: An input amplifier, a time base circuit, a function switching circuit, and a counting circuit. Changing the relationship of these basic elements with the FUNCTION switch enables the counter to perform its various functions.

5.2 BASIC CIRCUITS

Shaping and amplification of the input signal is accomplished by the input amplifier. The front panel controls for the input signal (AC/DC switch, ATTENUATOR switch, and the TRIGGER LEVEL control) all connect to this amplifier. Outputs from the amplifiers feed the switching circuits as either "count" or "stop/start" signals, depending on the operation being performed.

The counter time base provides the precise frequencies needed for rate and period measurements. Both multiplier and divider circuits process the output of a crystal oscillator to provide the frequencies required by the counter. The front panel TIME BASE and FUNCTION switches determine the disposition of these frequencies. Outputs from the time base are sent to the switching circuit as either "count" or "stop/start" signals. The INT-EXT switch and 1 MHz IN/OUT jack (rear panel) permit the use of an external oscillator.

The switching circuit regulates the passage of the trigger signal to the counting circuit. There are two elements in the switching circuit: A gate generator that receives "start/stop" signals and produces a control gate signal and an electronic switch that receives a "count" signal and produces the counting circuit trigger. The source of the "count" and "start/stop" signals is controlled by the front panel FUNCTION switch which controls the "Control and Reset logic". The front-panel indication for the condition of the switching circuit is provided by the Gate Lamp which is on when the electronic switch is closed.

The counting circuit is a chain of decades, or divide-by-ten elements, with their associated indicators and reset circuitry. The selections of decimal point position and annunciator legend are also functions of this circuit. The front-panel RECYCLE RATE control and RESET button are associated with this circuit, as is the rear-panel STORAGE switch.

5.3 CIRCUIT DESCRIPTIONS

The following paragraphs describe and explain the SD 7014 circuitry. A thorough understanding of these circuits should be obtained prior to any attempts to troubleshoot the counter. The SD 7014 Block Diagram, Drawing 25697, is the overall electronic diagram for the counter.

5.3.1 Power Supply

Refer to drawing 27475 -- the Power Supply Schematic.

Primary (ac) power is directed (via P1, the line cord, the POWER ON-OFF switch, and the 115-230 V switch) to the primary windings of Power Transformer T1. The air-circulating fan

(B1) receives its power via T1 primary winding 1-3. The T1 secondary windings transform the primary power to the following voltages: Winding 5-6 produces 170 V rms, center-tapped winding 7-9 produces 35 V rms, and center-tapped winding 10-12 produces 15.6 V rms.

+225 V Supply: The 170 V rms is applied to a fullwave bridge rectifier, CR103 through CR106, and filtered by capacitor C11.

+15 and -15 V Supplies: 35 V rms is routed to a dual-fullwave rectifier, CR107 through CR110. The outputs (approximately 20 V) are sent directly to the collectors of series regulators Q2 and Q1-- the + and - regulators, respectively. R119 and CR117 appropriately bias the base of Q2 to produce, in conjunction with the +5 V supply's constant-current-source Q104 circuitry, a regulated +15 V on the emitter of Q2. C6 is the associated filter capacitor. The -15 V supply operates in a like manner with constant-current-source Q106, filter capacitor C7, R120, and CR118.

(±)5 V Supplies: The 15.6 V rms is sent to a dual-fullwave rectifier (CR101, CR102, CR122, and CR123). Approximately 9 V is then applied to the collectors of two sets of cascaded (for current gain) emitter followers (Q3 and Q4, +5 V supply, and Q5 and Q107, -5 V supply). Each cascaded emitter follower is current supplied by a constant current source (Q104 for +5 V and Q106 for -5 V) and each 5 V supply is precisely regulated by a series regulator transistor (Q105 for +5 V and Q108 for -5 V). R116 (+5 V ADJ) and R127 (-5 V ADJ) allow manual control of the regulator transistor (Q105 and Q108) outputs. The 5 V supplies are referenced to the + and -15 V supply circuits in order to obtain more exacting regulation.

5.3.2 Input Amplifier and Shaper

Refer to Drawing 25345.

The input signal (via the INPUT connector, the AC-DC switch, and the ATTENUATOR switch) arrives at Pin 1 of the input amplifier. R1, C1, R2, CR1, and CR2 form the overload protection circuitry. The input signal is amplified by a factor of approximately .7 (Q1 and Q2 -- field effect transistor differential amplifier), is inverted by Q3, and is amplified and again inverted by Schmitt Trigger driver Q4. Q4 has an amplification factor of approximately six. The input signal passes through the Schmitt Trigger circuitry (Q5 and Q6) where it is shaped into a rectangular wave before being applied to saturated amplifier and invertor Q7. The output, at Pin 3 of the amplifier board, is a rectangular wave of approximately five volts equal to the input frequency. R3 (the amplifier balance potentiometer) and R27 (the Preset adjustment potentiometer), in conjunction with TRIGGER LEVEL control PRESET position, center the trigger at zero cross-over and set the operating level of the amplifier. CR5, CR6, and CR7 are used to regulate the supply voltages so that no noise, other than that contained in the input signal, is present at the output (Pin 3) of the amplifier.

5.3.3 Count Gates

Refer to Drawing 25370.

The input signal, from the input amplifier, arrives at Pin B. If the counter is not in the TEST function, the input signal passes through Nand Gate IC1B and through Nor Gate IC1C before being distributed, in Period X1, to the Control and Reset circuitry and to the Time Base Logic Circuits for all period measurements.

When TEST is selected, any input signal is removed from the counter's input amplifier by S1, Pin E is ground, and the shaped 1 MHz is fed through enabled IC1D and IC1C to output Pin C. This ground also disables gate IC1B.

In all positions of the FUNCTION switch, except the period positions, and if the counter is not in TEST, the input signal passes through Pin B, IC2D, IC4A, differentiator C1 and R2, and Count Gate IC4B. The gated count output at Pin Y is available only for the period of time (gate time) determined by control gate signals A and B.

If the counter is not in TEST and is in a PERIOD position, Gate IC2D is disabled, IC2C is enabled, and the 1 MHz signal is fed, via IC4A, to Count Gate IC4B. There is a gated 1 MHz signal at output Pin Y during the gate time (determined by summing the Gate A and Gate B signals. If the counter is in TEST and in a PERIOD position, a shaped 1 MHz signal is fed to Pin C and a gated 1 MHz signal is present at Pin Y. IC3 allows the counting gates to accept additional inputs. In TEST (or TIM) Pin E is ground; IC2A and IC2B (via CR1) are enabled.

5.3.4 Count and Display

Refer to Drawing 25366.

5.3.4.1 Indicator Logic Section

This section provides the circuits necessary to count the output signal from the Count Gate (IC4B Pin 8) and store the seven digits of the count during the GATE ON interval. Seven identical count decades (IC19 - IC25) and associated storage registers (IC10 - IC16) are cascaded to achieve this function. Each decade is essentially four flip-flops connected as a binary coded decimal counter. It provides a "÷10" output to trigger the next decade counter stage and delivers its count at the end of the GATE ON interval to be stored until the next counting cycle. Each decade is reset to zero by the RESET pulse. When the TRANSFER signal occurs, the information present at the Data Inputs (Pins 2, 3, 6 and 7) of each storage register is transferred to the Q outputs (Pins 16, 9, 15, and 10) and remains there until the next TRANSFER pulse. The Q outputs are routed to the Readout and Drivers Section.

5.3.4.2 Readout and Drivers Section

This section converts the stored BCD information from the Indicator Logic section into 10 digit parallel decimal form to drive the readout tubes. Seven identical BCD-Decimal decoder drivers (IC1 - IC7) and cold cathode gas filled indicator tubes are used.

The BCD-Decimal decoder consists of TTL (transistor-transistor logic) circuits which select one of ten built in decimal output drivers (high breakdown NPN transistors) which in turn drives the readout tube. Decimal point position selection

and drive is provided by a ground supplied by FUNCTION switch positions 3 through 6 and 8 through 12 (see Block Diagram, S4-A). The automatic units-of-measure indications operate in a like manner except the ground is supplied by wafer S4-B of the FUNCTION switch.

5.3.4.3 Off-Scale Indicator

This circuit is designed to provide an off-scale indication (OS lamp lighted) whenever the measured input signal exceeds the readout limits of the display. The off-scale indicator circuit comprises the "CARRY" line, IC29, IC28, Q1, the $\overline{\text{RESET}}$ line, and the TRANSFER line.

The negative going CARRY pulse, from the most significant digit decade, arrives at Gate A of IC29 (an invertor) and with its positive going trailing edge, via the clock input of flip-flop B IC28, sets the Q output of F.F.B. to true (high -- approx. 5 V). Upon arrival of the positive TRANSFER pulse, gate C of IC29 is enabled and its low output presets F.F.A IC28 which produces the high output signal required by the Q output (F.F.A IC 28) to turn on Q1 and light the OS (off-scale lamp).

F.F.A remains in the lamp-lit condition until two things happen; the CARRY pulse is no longer generated, and a TRANSFER pulse occurs. This is because each time the negative $\overline{\text{RESET}}$ pulse clears F.F.B causing the Q output (F.F.B) to go low, the next CARRY pulse toggles F.F.B. Flip-flop A is the "slave" of "master" F.F.B and at the time of each TRANSFER pulse, no matter what its state is, F.F.A assumes the state of F.F.B.

The OS lamp is turned off in the following manner. A $\overline{\text{RESET}}$ signal clears F.F.B. No CARRY pulses are generated (the signal on the readout digits is within the limits of the display). A TRANSFER signal occurs. The TRANSFER pulse and the high $\overline{Q}$ output of F.F.B (F.F.B has been cleared) enable gate B IC 29. The low output of gate B clears F.F.A of IC28 which makes the Q output of F.F.A go low which, in turn, shuts off transistor Q1. The OS lamp goes out because it no longer has a path to ground.

5.3.5 One Megahertz Clock

Refer to Drawing 25670.

The SD 7014 1 MHz clock is a crystal (Y1) controlled field effect transistor (Q4) oscillator. The significant frequency determining components are C13 (COARSE FREQ. ADJ.), C2 (FINE FREQ. ADJ.), Y1, and capacitor C4. Saturated amplifier Q5 accepts the 1 megahertz oscillator output at its base. Q5 inverts the signal and provides the 1 MHz with approximately 5 volts of swing (ground to +5 volts) at TP1.

If the 1 MHz INT-EXT switch is in INT, the oscillator output at Pin C is routed (via the INT-EXT switch, Pin B, and Resistor R1) to the Schmitt trigger (transistors Q1 and Q2). The Schmitt trigger shapes the 1 MHz into a rectangular wave and saturated amplifier Q3 provides the shaped 1 MHz with 5 volts of swing.

If the 1 MHz INT-EXT switch is in EXT, the Pin C oscillator output is not used. The external oscillator's input to the SD 7014 is applied to Pin B, as above.

5.3.6 Time Base Logic

Refer to Block Diagram (25697) and Drawing 25362.

This relatively simple circuitry operates on the principle that dividing the input frequency (by a divisor of 10), since the internal 1 MHz is the signal being counted, is the same as multipling the period by a factor of ten.

As a time base this circuit operates in the following manner. FUNCTION switch S4-G picks off the scaled down 1 MHz at the selected pin (either 2, 3, 4 or 19) and, via S4-E, routes this signal to the start and stop pins (F and E) of the Control and Reset PC board.

As a period multiplier the Time Base Logic operates as follows. The input signal arrives at Pin U. The FUNCTION switch S4-C, for example, is in the PERIOD x 10^4 position (a ground is applied to Pin 16). This disables IC5B (the time base signal is stopped at Pin 5 of IC5B) and via invertor IC5A, enables IC5D. The signal is inverted by IC5C and enters the decade chain at Pin 14 of IC6. Its path to Pin 2 is IC7B, IC7C, IC8, IC9B, IC9C, IC10, IC11B, IC11C, and IC12. From Pin 2 (via S4-G, S4-F, and S4-E) the signal is routed to Pins F and E of the Control and Reset assembly -- the start and stop signal pins.

5.3.7 Control and Reset

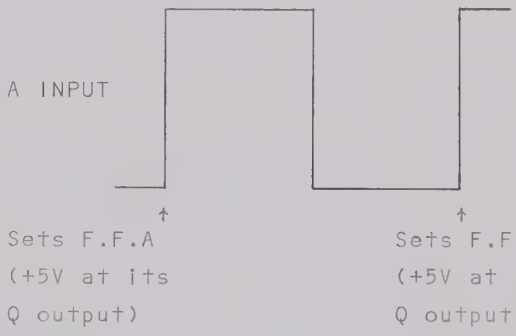
Refer to Block Diagram and Drawing 25398.

This circuitry is the "heart" of the counter. All counter synchronization procedures are accomplished by this board -- the Count Gate-controlling-signals (Gates) A and B (see Paragraph 5.3.3), the RESET pulse, the TRANSFER pulse, and the "End of Count" pulse are all produced by the Control and Reset circuitry. The Display Time Generator is also located upon this PC assembly.

5.3.7.1 Count Gate Control

PERIOD X1 -- The amplified and shaped A input is applied to Pins F and E, Control and Reset assembly, by FUNCTION switch S4-F and S4-E. The first positive-going transition of the input pulse "clocks" F.F. IC3A which produces the +5 V on its Q output (see Figure 13). F.F. IC3B does not produce +5 V on its Q output during this first positive transition because, the Q output of F.F.A is connected to the D input of F.F.B which means F.F.A must be set before F.F.B can have a +5 V Q output.

FIGURE 13



At this point (F.F.A set and F.F.B clear), Count Gate IC4B (Drawing 25370) is enabled and the shaped 1 MHz is being sent to the display. The next positive transition of the input signal sets F.F. IC3B, its $\overline{Q}$ output goes low (Count Gate IC4B is disabled - Drawing 23370), and its Q output goes high (Gate IC6A is enabled and produces the End-of-Count signal.

PERIOD FUNCTIONS (Except X1) -- Operation is the same as above except the input applied to Control and Reset assembly Pins F and E is the counter's input signal divided by some factor of ten. This division is accomplished in the Time Base circuitry (see Paragraph 5.3.6).

RATE FUNCTIONS -- Operation same as above except the Count and Reset assembly Pins F and E input is the selected (FUNCTION switch S4) "sample time" signal generated in the Time Base circuitry by dividing the shaped 1 MHz oscillator frequency.

COUNT FUNCTION -- When the COUNT position is selected, ground is applied to Preset Pin 4 of IC3A and Clear Pin 13 of IC3B (via NOR gate IC4B and invertor IC4A). As a result, the IC3A Q and IC3B $\overline{Q}$ outputs are high and the shaped A input is routed, via Count Gate IC4B (Drawing 25370), to the display. IC4B (Drawing 25370) will remain enabled as long as the ground on Pin B of the Control and Reset assembly is applied.

HOLD FUNCTION -- Selection of the HOLD position places a ground on Pin 6 of the Control and Reset assembly. This ground presets ($\overline{Q}$ output low) F.F. IC3B and, via NOR gate IC5C and invertor Q5, clears F.F. IC3A ($\overline{Q}$ output low). The two "lows", in turn, indefinately disable Count Gate IC4B (Drawing 25370). The counter remains in HOLD until the ground is removed, via FUNCTION switch S4-C.

T.I.M FUNCTION -- The external start and stop signals (contact closures to ground) from the START and STOP connectors are applied to the Control and Reset assembly Pins D and 3 respectively. Since Pin C of the C&R assembly is high, the low start signal on Pin 2 IC1A produces a high output on Pin 3. This high is inverted by IC1B, is sent via switch S4-E (Block Diagram) to Pin F on the C&R assembly, is inverted by IC6C, and "clocks" F.F. IC3A's Q output to +5V. The ground at Pin B of the C&R assembly (for time interval measurements the FUNCTION switch is placed in COUNT) has already preset F.F. IC3A and cleared F.F. IC3B. The +5 V at the Q output of F.F. 3A, in conjunction with the +5 V $\overline{Q}$ output of F.F. IC3B, enables Count Gate IC4B (Drawing 25370) and IC4B sends the shaped 1 MHz from the time base to the readout circuit. In a like manner as with the start signal, the stop signal arrives at Pin E, C&R assembly, is inverted by IC6B, and toggles F.F. IC3B. The $\overline{Q}$ output of IC3B goes low and the Q goes high. The high at the Q output produces the End-of-Count signal at gate IC6A while the $\overline{Q}$ output of IC3B disables Count Gate IC4B (Dwg. 25370). The time interval is displayed, in microseconds, on the readout.

TEST FUNCTION -- In TEST, the Start and Stop Binary IC3A and B has one of the four selectable time bases as its start and stop inputs (FUNCTION switch RATE positions). Operation of IC3 is identical to its Rate positions operation. See Paragraph 5.3.3 for the differences in Count Gate operation.

5.3.8 Timing Pulses

The End-of-Count signal is produced by gate IC6A. The output of this gate is positive until End-of-Count (both Q outputs of Binary IC3 are high (+5 V). See Figure 14.

The EOC signal, via R5, is applied to the Base of Q2. Q2 turns off and C3 begins to charge (at a rate determined by R7 [C&R assembly], R7 [Recycle Rate], the +225 V supply, and CR3) to the positive value which will fire unijunction transistor Q3. The negative 6 V pulse generated by Q3 is applied to Reset One-shot IC5A & B. The one-shot's output (Reset pulse), 100 μ sec., 5 volt negative going pulse, is fed to saturated amplifier Q4, to $\overline{\text{RESET}}$ Pin 8 (C&R assembly) and to the Time Base Inhibit One-shot IC4 C&D. Depressing S9 also causes the Reset pulse to be generated.

The output of the Time Base Inhibit One-shot, approx. 55 m sec, 5 volt negative going pulse, has two major functions. This output inhibits the time base, at Pin 8 (C&R assembly), while it clears the Start-Stop Binary IC3A & B. This pulse clears F.F. IC3A via NOR gate IC5C and invertor Q7 and clears F.F. IC3B via NOR gate IC4B and invertor IC4A.

The EOC signal (via C8, R19 and CR4) is delayed and applied to saturated amplifier Q6. When the STORAGE ON-OFF switch is in OFF, Pin S of the C&R assembly is grounded and Q6 is held off so all counting information is constantly being transferred to the readout. CR4 isolates this ground from the Reset and Start-Stop circuitry.

IC2C and D compose the Minimum Lamp Time One-shot. The output of NOR gate IC2A is either the IC2C or D output or the time Measurement Interval Gate IC2B is enabled - whichever is longer. Q1 is the Gate Lamp driver.

The "gate on" signal at Pin 14 of the C&R assembly is provided to give the operator added capabilities and is not used by the counter proper.

Pin 17, labeled INHIBIT RESET, is used when the counter has the BCD outputs option and is being operated with a print-out device. The printer supplies this signal to prevent the counter from recycling until the printer is ready to accept new information.

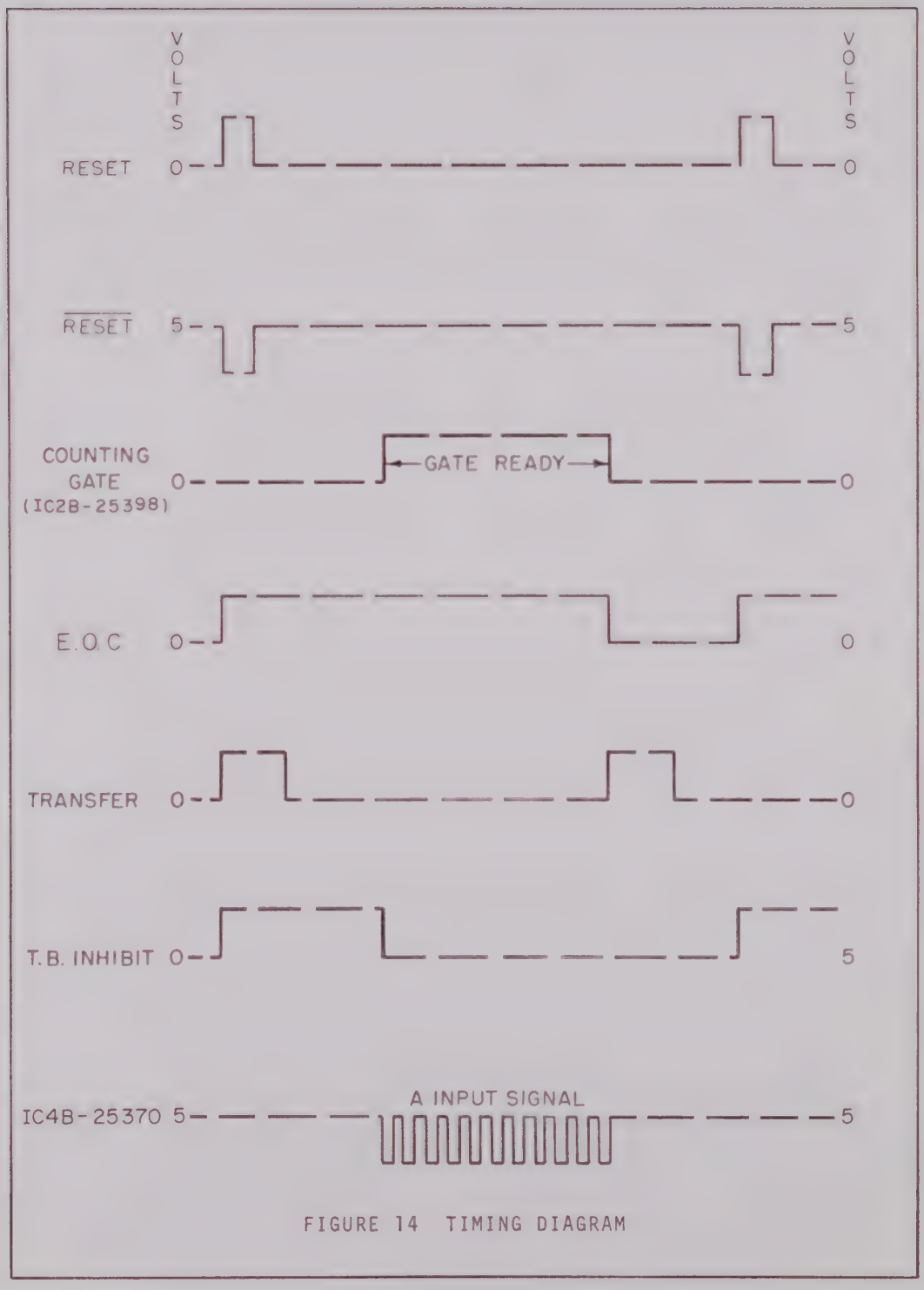


FIGURE 14 TIMING DIAGRAM

CHAPTER 6

PARTS IDENTIFICATION

TIME BASE LOGIC PC ASSEMBLY
PART NUMBER 25365

Ref.	Description	SD Part No.
C1	Capacitor, .05 Disc., 12V	C0672
C2	Same as C1	
C3	Same as C1	
C4	Same as C1	
C5	Same as C1	
C6	Same as C1	
C7	Same as C1	
IC1	Integrated Circuit (SN7490)	19711
IC2	Same as *IC1*	
IC3	Integrated Circuit (SN15846)	19716
IC4	Same as *IC1*	
IC5	Same as *IC3*	
IC6	Same as *IC1*	
IC7	Same as *IC3*	
IC8	Same as *IC1*	
IC9	Same as *IC3*	
I10	Same as *IC1*	
I11	Same as *IC3*	
I12	Same as *IC1*	
	Unless othersiwe noted, all resistors are composition carbon, 1/4W, 5%.	
R1	Resistor, 5.6KΩ	R0821
R2	Same as R1	
R3	Same as R1	
R4	Same as R1	
R5	Same as R1	

POWER SUPPLY PC ASSEMBLY
PART NUMBER 27479

Ref.	Description	SD Part No.
C102	Capacitor, 1μf	C0314
C103	Capacitor, .1μf, 100V	C0786
CR101	Diode IN4005	CR0284
CR102	Same as CR101	
CR103	Same as CR101	
CR104	Same as CR101	
CR105	Same as CR101	
CR106	Same as CR101	
CR107	Same as CR101	
CR108	Same as CR101	
CR109	Same as CR101	
CR110	Same as CR101	
CR114	Diode, Zener, IN752-A	CR0064
CR115	Diode, IN4370, 2.4V	CR0309
CR117	Diode, Zener, IN966B	CR0213
CR118	Same as CR117	
CR119	Same as CR114	
CR120	Same as CR115	
CR122	Diode, IN4719	CR0251
CR123	Same as CR122	
R101	Resistor, 180k, 1/2W	R0283
R110	Resistor, 1.2k,	R0809
R111	Resistor, 390Ω	R0880
R112	Resistor, 1k	R0765
R113	Resistor, 15Ω	R1607
R114	Resistor, 100Ω	R0966
R115	Resistor, 150Ω	R0983
R116	Resistor, 100Ω, POT, PC (T-100)	R2376
R117	Resistor, 47Ω	R0743
R118	Resistor, 47Ω, TM 1/4	R2320
R119	Resistor, 470Ω	R1044
R120	Same as R119	
R121	Same as R111	
R122	Same as R110	
R123	Resistor, 4.7k	R0892
R124	Same as R113	
R125	Same as R112	

Ref.	Description	SD Part No.
R126	Same as R117	
R127	Same as R116	
R128	Same as R115	
R129	Same as R118	
R130	Same as R114	

COUNT GATES PC ASSEMBLY
PART NUMBER 25373

C1	Capacitor, 220 pF	C0538
C2	Capacitor, .05 µF, 12V	C0672
C3	Same as C2	
C4	Same as C2	
CR1	Diode, IN4151	CR0150
IC1	Integrated Circuit (SN7400N)	19705
IC2	Same as IC1	
IC3	Same as IC1	
IC4	Integrated Circuit (SN7420N)	25713

Unless otherwise noted, all resistors are composition carbon, 1/4W, 5%.

R1	Resistor, 10KΩ	R0766
R2	Resistor, 470Ω	R1044
R3	Resistor, 5.6kΩ	R0821

1 MHz CLOCK PC ASSEMBLY
PART NUMBER 25671

C1	Capacitor, 22 pF, 500V DSM	C0529
C2	Capacitor, Variable, 9-35 Trimmer	C0709
C3	Capacitor, .05 µF, 100V Cer Disc	C0708
C4	Capacitor, 68 pF, 500V DSM	C0635
C5	Same as C3	
C6	Capacitor, .01 µF, 100V Cer Disc	C0556
CR1	Diode, IN4151	CR0150
Q1	Transistor, 2N3646	Q0218
Q2	Same as Q1	
Q3	Same as Q1	
Q4	Transistor, TIS-34	Q0244
Q5	Same as Q1	

Ref.	Description	SD Part No.

Unless otherwise noted, all resistors are composition carbon, 1/4W, 5%.

R1	Resistor, 1KΩ	R0765
R2	Resistor, 15KΩ	R0728
R3	Resistor, 470Ω	R1044
R4	Resistor, 1.2KΩ	R0809
R5	Resistor, 680Ω	R1234
R6	Resistor, 47Ω	R0743
R7	Same as R1	
R8	Same as R3	
R9	Same as R3	
R10	Resistor, 100KΩ	R0741
R11	Resistor, 820Ω	R0762
R12	Resistor, 2.2KΩ	R0749
R13	Same as R11	
R14	Same as R3	
Y1	Crystal, CR-18U	Y0019

SEVEN DIGIT PC ASSEMBLY
PART NUMBER 25942

C1	Capacitor, .01 F, 500V Disc	C0423
C2	Same as C1	
C3	Same as C1	
C4	Same as C1	
C5	Capacitor, .05 F, 12V Disc	C0672
C6	Same as C5	
C7	Same as C5	
C8	Same as C5	
C9	Same as C5	
C10	Same as C5	
C11	Same as C5	
C12	Same as C5	
C13	Same as C5	
IC1	Integrated Circuit (SN7441N)	19707
IC2	Same as IC1	
IC3	Same as IC1	
IC4	Same as IC1	
IC5	Same as IC1	
IC6	Same as IC1	
IC7	Same as IC1	

Ref.	Description	SD Part No.
IC8	Not Used	
IC9	Not Used	
IC10	Integrated Circuit (SN7075N)	25731
IC11	Same as IC10	
IC12	Same as IC10	
IC13	Same as IC10	
IC14	Same as IC10	
IC15	Same as IC10	
IC16	Same as IC10	
IC17	Not Used	
IC18	Not Used	
IC19	Not Used	
IC20	Integrated Circuit (SN7490N)	19711
IC21	Integrated Circuit (SN7090N)	25732
IC22	Same as IC21	
IC23	Same as IC21	
IC24	Same as IC21	
IC25	Same as IC21	
IC26	Not Used	
IC27	Not Used	
IC28	Integrated Circuit (SN7474N)	25241
IC29	Integrated Circuit (SN7410N)	19706
Q1	Transistor (2N3646)	Q0218

Unless otherwise noted, all resistors are composition carbon, 1/4W, 5%.

R1	Resistor 1/2W, 5% 39k	R0282
R2	Same as R1	
R3	Same as R1	
R4	Same as R1	
R5	Same as R1	
R6	Same as R1	
R7	Same as R1	
R8	Not Used	
R9	Not Used	
R10-13	Resistor Network, BCD	27867
R14-17	Same as R10-13	
R18-21	Same as R10-13	
R22-25	Same as R10-13	
R26-29	Same as R10-13	
R30-33	Same as R10-13	
R34-37	Same as R10-13	
R38-41	Not Used	
R42-45	Not Used	
R46	Resistor 1/4W, 5% 47Ω	R1044
R47	Resistor 1/4W, 5% 27Ω	R1548
V1	Readout Tube (NL905)	V0124
V2	Same as V1	
V3	Same as V1	
V4	Same as V1	
V5	Same as V1	
V6	Same as V1	
V7	Same as V1	
V8	Same as V1 (optional)	
V9	Same as V1 (optional)	

AMPLIFIER AND SHAPER ASSEMBLY
PART NUMBER 25393

C1	Capacitor, 47 pF, 5% MICA	C0848
C2	Capacitor, .05 µF, CERAMIC	C0672
C3	Same as C2	
C4	Same as C2	
C5	Same as C2	
C6	Capacitor, 100 pF, 5% MICA	C1156
C7	Same as C2	

Ref.	Description	SD Part No.
C8	Same as C2	
C9	Same as C1	
C10	Same as C2	
C11	Same as C2	
CR1	Diode, IN4151	CR0150
CR2	Same as CR1	
CR3	Diode, IN751A Zener	CR0345
CR4	Diode, IN751A Zener	CR0095
CR5	Same as CR4	
CR6	Same as CR4	
CR7	Same as CR4	
CR8	Same as CR4	
CR9	Same as CR4	
CR10	Same as CR4	
Q1	Transistor, TIS34	Q0244
Q2	Same as Q1	
Q3	Transistor, 2N3640	Q1078
Q4	Transistor, 2N3646	Q0218
Q5	Transistor, 14092	14092
Q6	Same as Q5	
Q7	Same as Q5	
	Unless otherwise noted, all resistors are composition carbon, 1/4W, 5%.	
R1	Resistor, 100KΩ	R0741
R2	Resistor, 1MΩ	R0962
R3	Potentiometer, 2KΩ	R2382
R4	Resistor, 6.8KΩ	R0696
R5	Resistor, 4.7KΩ	R0892
R6	Same as R5	
R7	Resistor, 22KΩ	R0768
R8	Resistor, 39KΩ	R0748
R9	Resistor, 4.7KΩ, 1/4W, 10%	R2053
R10	Resistor, 1KΩ	R0765
R11	Resistor, 2.7KΩ	R0937
R12	Same as R10	
R13	Resistor, 470Ω	R1044
R14	Resistor, 100Ω	R0966
R15	Same as R13	
R16	Resistor, 680Ω	R1234
R17	Resistor, 1.5KΩ	R0783
R18	Same as R13	
R19	Resistor, 47Ω	R0743
R20	Resistor, 3.3KΩ	R0742
R21	Same as R1	
R22	Resistor, 3.9KΩ	R0939
R23	Same as R13	
R24	Same as R17	
R25	Same as R17	
R26	Resistor, 1.2KΩ	R0809
R27	Resistor, 5K POT CTS SERIES 340	RXXXX

CONTROL AND RESET PC ASSEMBLY PART NUMBER 25401

C1	Capacitor, .001 μF	C0235
C2	Capacitor, 10 μF, 6V	C1091
C3	Capacitor, 4.7 μF, 35V	C0406
C4	Same as C1	
C5	Capacitor, .01 μF, 100V	C0556
C6	Capacitor, .1 μF, 20V	C0806
C7	Same as C5	
C8	Same as C1	
C9	Capacitor, 56 μF,6V	C1090
C10	Capacitor, .05 μF, 12V	C0672
C11	Same as C10	
C12	Same as C10	
C13	Same as C10	
C14	Same as C10	
C15	Same as C10	
CR1	Diode, IN4151	CR0150
CR2*	Same as CR1	
CR3	Same as CR1	
CR4	Same as CR1	
IC1	Integrated Circuit (SN7400N)	19705
IC2	Same as IC1	
IC3	Integrated Circuit (SN7474N)	19706
IC4	Same as IC1	
IC5	Integrated Circuit (SN7410N)	19706
IC6	Same as IC1	
Q1	Transistor, 15840	15840
Q2	Transistor, 2N3646	Q0218
Q3	Transistor, 2N4870	Q0266

Ref.	Description	SD Part No.
Q4	Transistor, 2N3643	Q0179
Q5*	Same as Q2 (Ser. No. 101-200)	
Q6	Same as Q4	
Q7	Same as Q2	
	Unless otherwise noted, all resistors are composition carbon, 1/4W, 5%.	
R1	Resistor, 10KΩ	R0766
R2	Resistor, 470Ω	R1044
R3	Resistor, 1KΩ	R0765
R4	Resistor, 220KΩ	R0967
R5	Same as R3	
R6*	Same as R2	
R7	Same as R1	
R8	Resistor, 3.3KΩ	R0742
R9	Same as R1	
R10	Same as R1	
R11	Same as R1	
R12	Same as R2	
R13	Same as R3	
R14	Same as R2	
R15	Same as R3	
R16	Same as R2	
R17	Same as R3	
R18	Resistor, 5.6KΩ	R0821
R19	Same as R3	
R20	Same as R3	
R21	Same as R2	
R22	Same as R18	
R23	Same as R1	
R24	Same as R18	
R25	Same as R3	
R26	Same as R18	
R27	Same as R1	
R28	Same as R1	

* An SD 7014 with Serial Number of 200 or larger does not use these components.

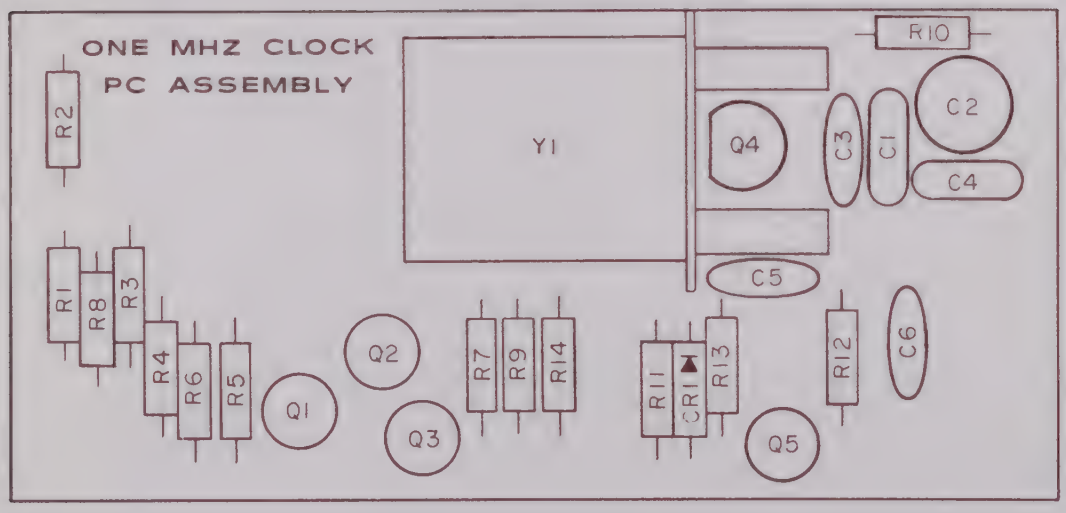
SD 7014 FINAL ASSEMBLY
PART NUMBER 24660

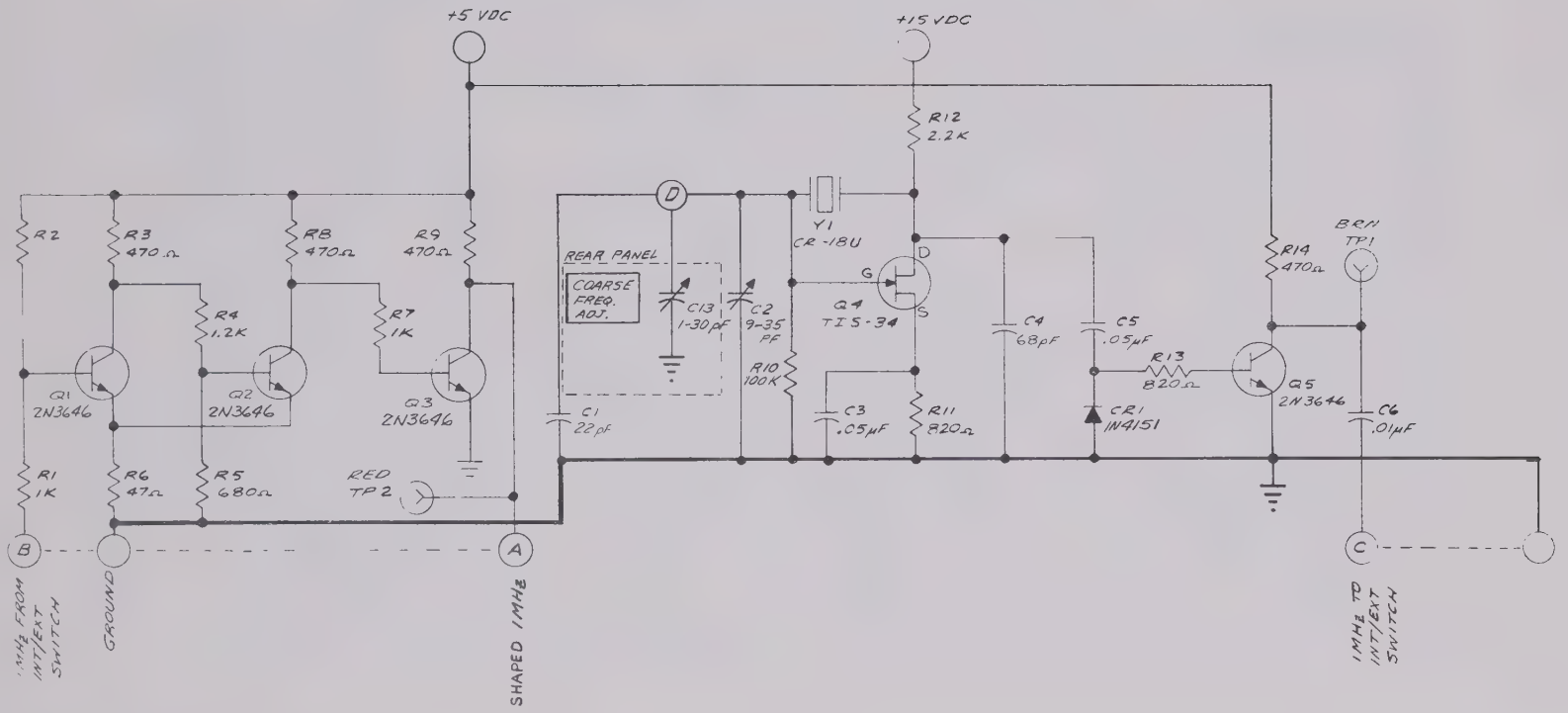
B1	Fan	H1786
C1	Capacitor, .1 µF, 500V	C1106
C2	Capacitor, 2 pF, DISC	C0261
C3	Capacitor, 1 pF, DISC	C0258
C4	Capacitor, 100 pF, Dipped Mica	C1075
C5	Capacitor, 10 pF, Dipped Mica	C1160
C6	Capacitor, 1000 µF, 65V	13490
C7	Same as C6	
C8	Not Used	
C9	Capacitor, 13000 µF, 12V	C1122
C10	Capacitor, 1000 µF, 15V	C1152
C11	Capacitor, 20 µF, 400V	C1150
C12	Capacitor, .01 µF, 100V	C0556
C13	Capacitor, variable piston type, 1-30 pF	C1153
C14	Capacitor, 15 pF	C0528
C15	Same as C14	
C16	Capacitor, .005 µF	C0221
C17	Same as C16	
F1	Fuse, 1 amp., quick acting	F0001
I1	Indicator Lamp, with retainer	0074
I2	Lamp incandescent	0075
I3	Same as *I2*	
I4	Same as *I2*	
I5	Same as *I2*	
J1	Connector, BNC	J0260
J2	Same as J1	
J3	Same as J1	
J4	Same as J1	
J5	Same as J1	
J6	Same as J1	
Q1	Transistor, 2N4918	Q0268
Q2	Transistor, 2N4921	Q0267
Q3	Same as Q2	
Q4	Same as Q2	
Q5	Same as Q1	

Unless otherwise noted, all resistors are composition carbon, 1/4W, 5%.

R1	Resistor, 1MΩ	R0962
R2	Resistor, 910KΩ, 1/2W 5%	R0359

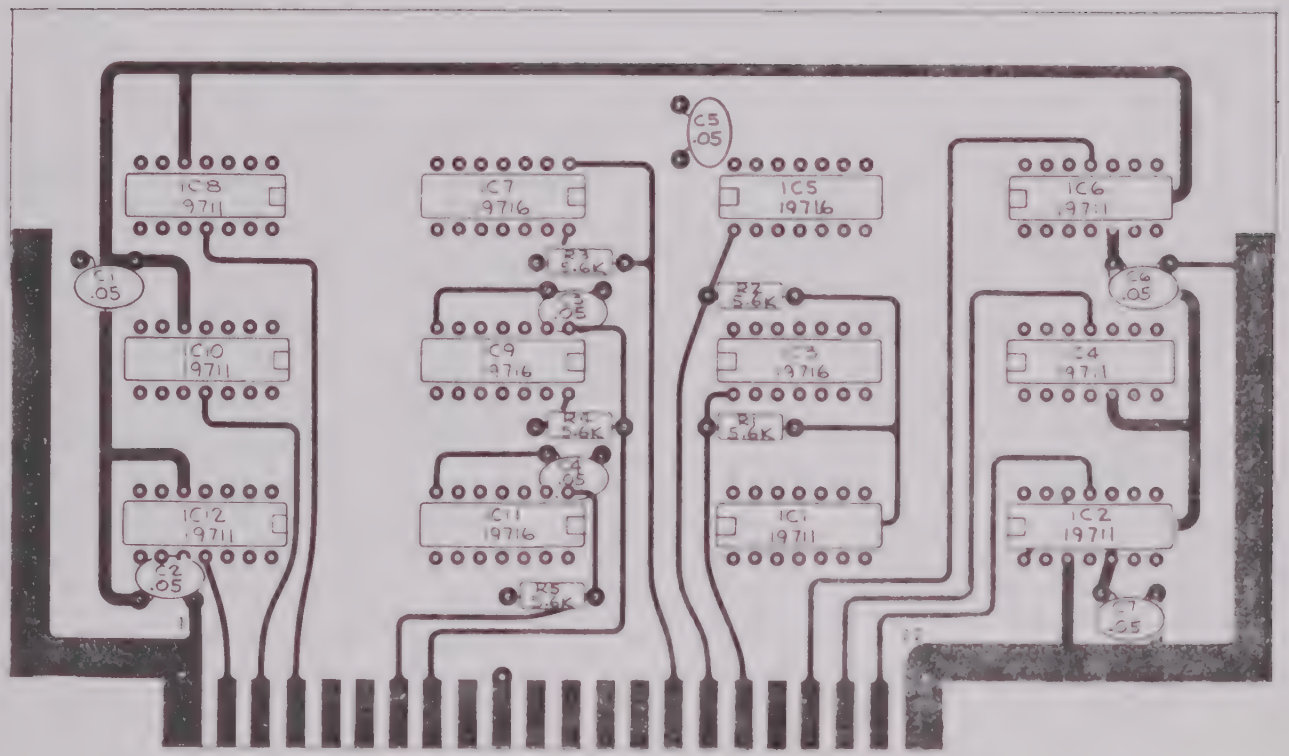
Ref.	Description	SD Part No.
R1	Resistor, 10KΩ	R0766
R4	Resistor, 270Ω	R0694
R5	Resistor, 100KΩ	R0741
R6, 11	Potentiometer, 5KΩ, with switch	25339
R7, 8	Potentiometer, 2MΩ, with switches	R2367
R9	Resistor, 27Ω	R1548
R12	Resistor, 470Ω	R1044
S1	Switch, Attenuator 2701I	
S2	Switch, ac-dc	S0149
S3	See R6, above	
S4	Switch, Function	25330
S5	witch (Line), slide 4PDT	S036
S6	See R7, above	
S7	Switch (storage), slide, DPDT	S0110
S8	See R7, above	
S9	Switch (Reset), push-button	S0160
S10	Switch (Norm-TIM), slide	S0362
S11	Switch (Int-Ext), same	
T1	rmer, power	25205
	iator Block Assembly	25665



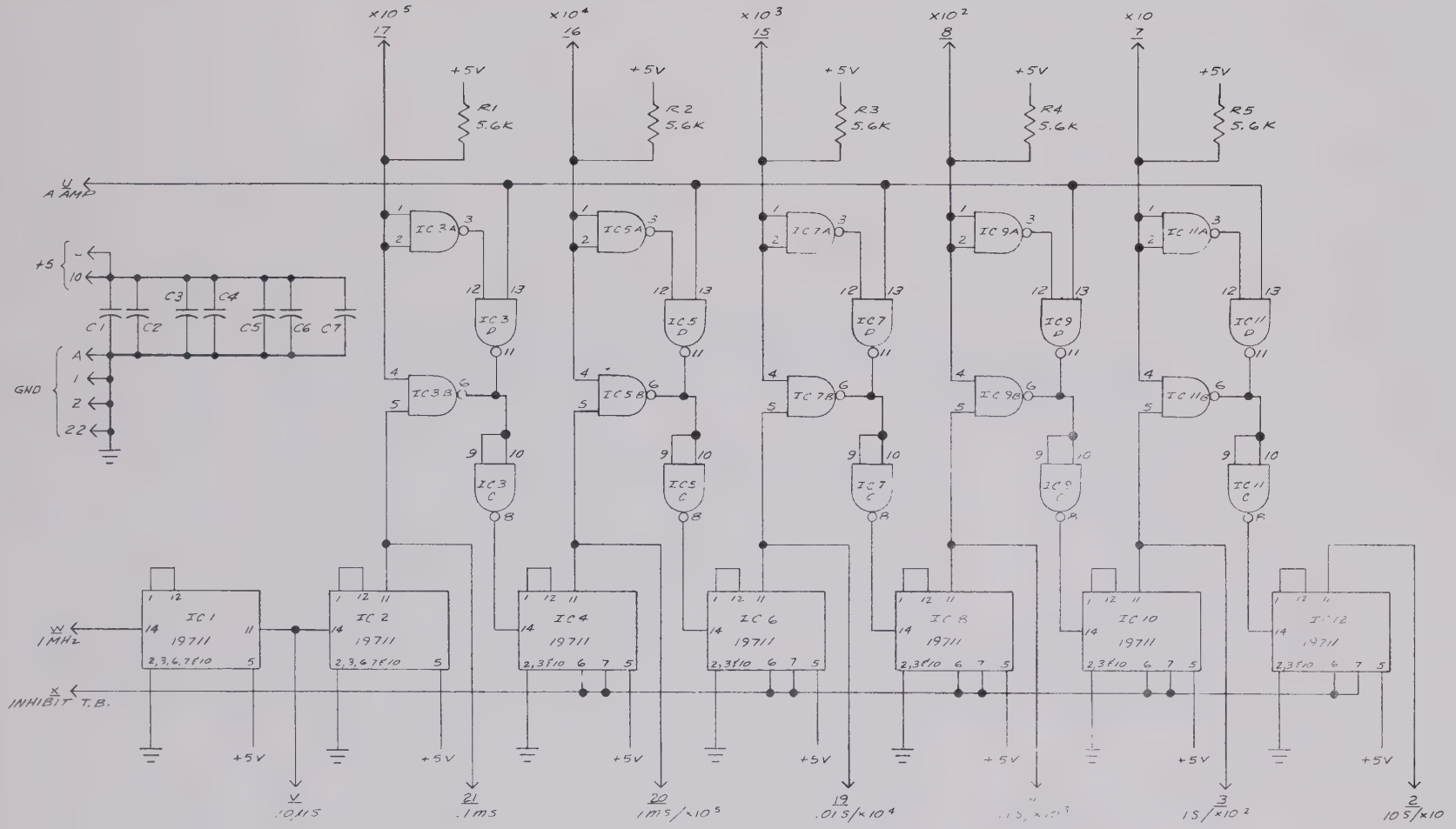


NOTE:
UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE ±5%, 1/4 W

Schematic 25670
1 MHz Clock PC Assembly



Time Base Logic PC Board
Part Number 25365
Access: Top Cover



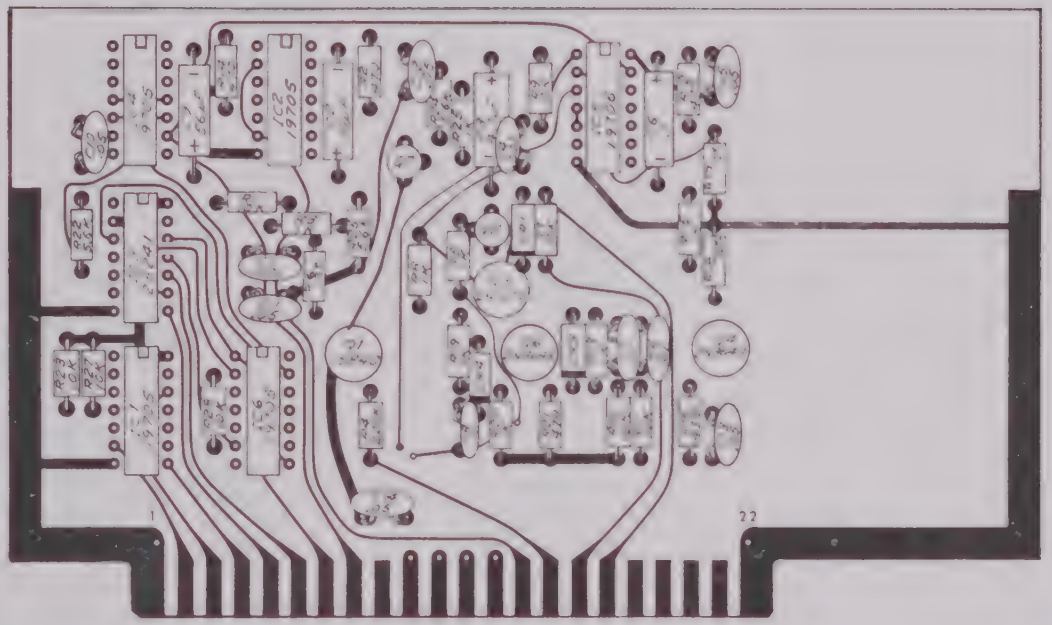
NOTE:

1) RESISTORS:
   POWER - 1/4 W.
   TOL - -5%

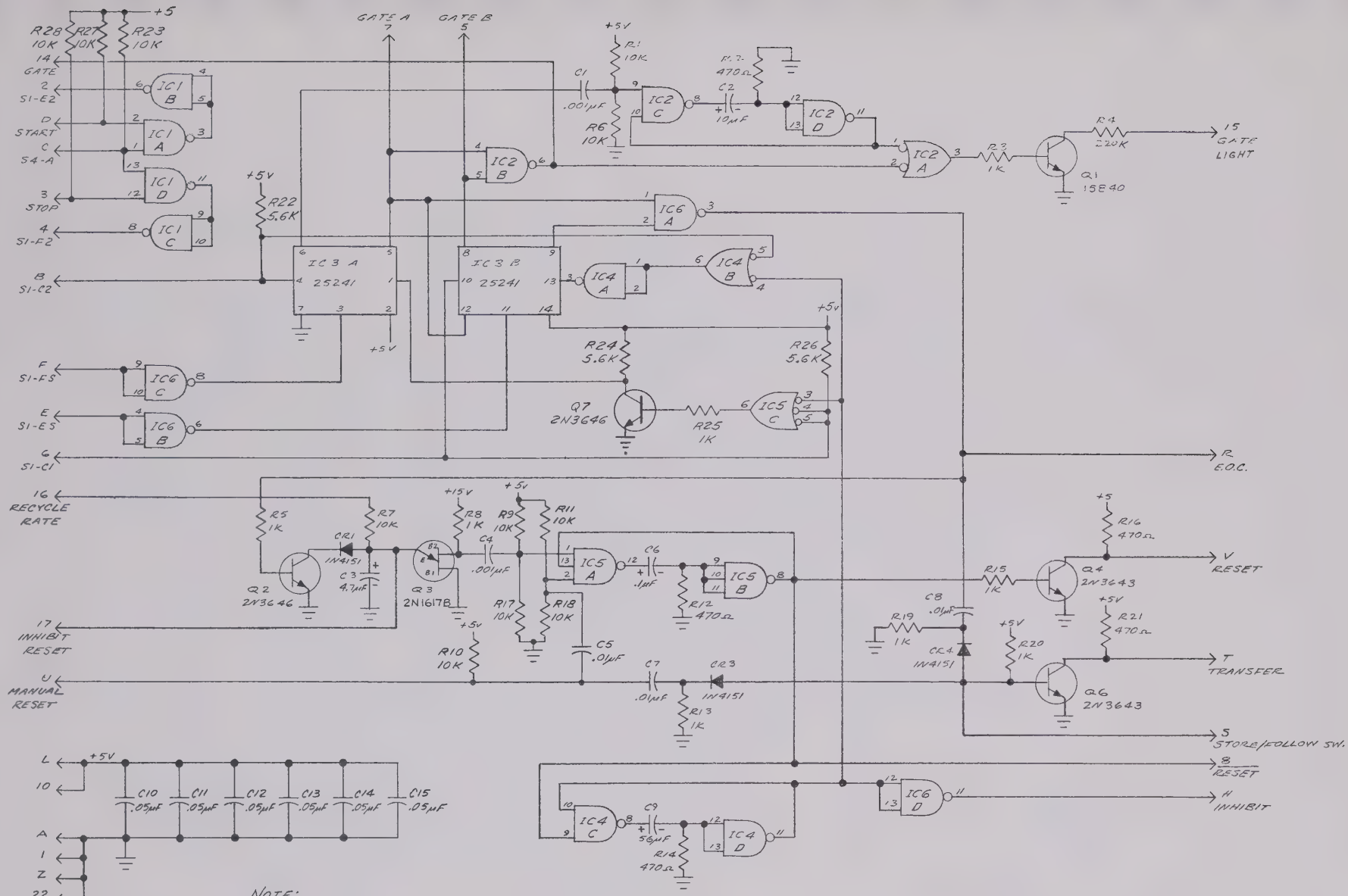
2) CAPACITORS:
   VALUE - .05 μF.
   VOLTAGE - 12V.

3) IC3, IC5, IC7, IC9 & IC11 ARE 19716
   PIN 14 IS + 5.
   PIN 7 IS GND.

Schematic 25362 XP-3
Time Base Logic PC Assembly



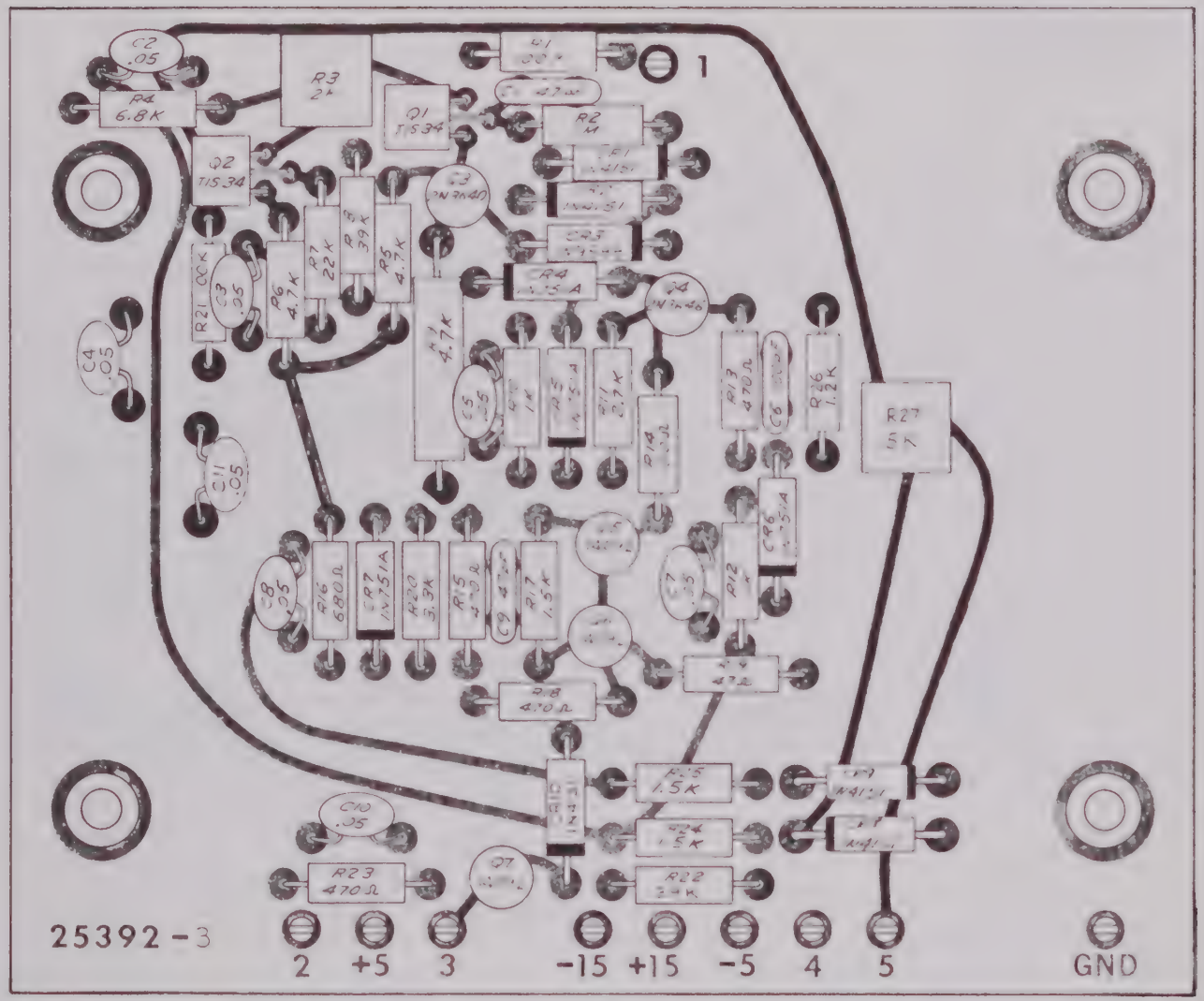
SYSTRON DONNER CORPORATION CONCORD, CALIFORNIA	DATA & RESET PC ASSEMBLY
MATERIAL	DWG NO 25401 / ISSUE B



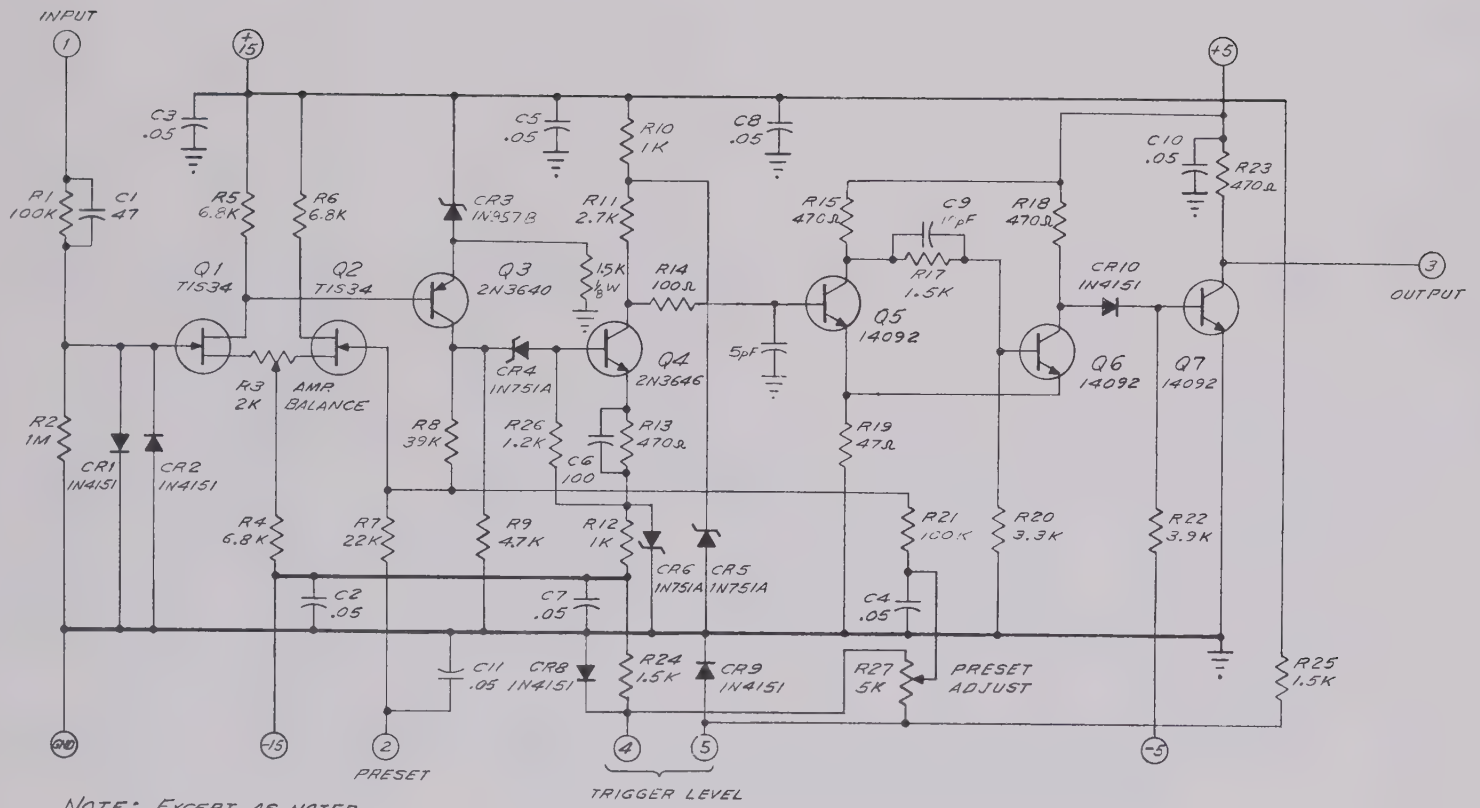
NOTE:

1) IC1 - 19705, GND-PIN 7, +5V-PIN 14.
   IC2 - ↓
   IC4 - ↓
   IC5 - 19706
   IC6 - 19705
2) RESISTORS - 1/4W, 5%.

SYSTRON DONNER CORPORATION CONCORD, CALIFORNIA	SCHEMATIC CONTROL & RESET PC ASSEMBLY
MATERIAL	DWG NO. 25398 ISSUE B



Amplifier-Shaper PC Board
Part Number 25393
Access: Bottom Cover

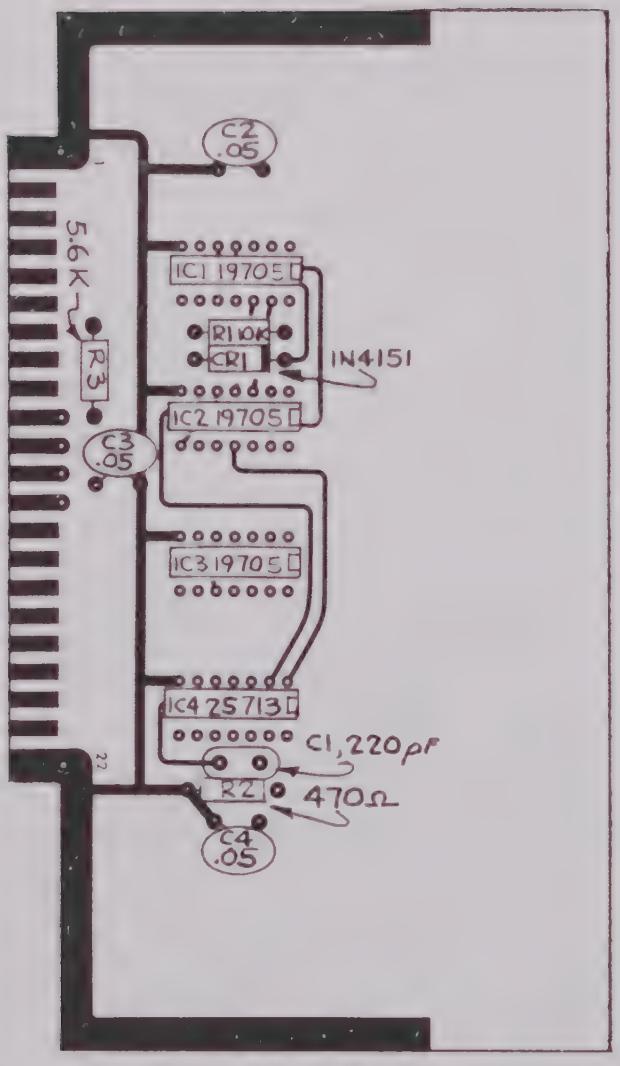


NOTE: EXCEPT AS NOTED.

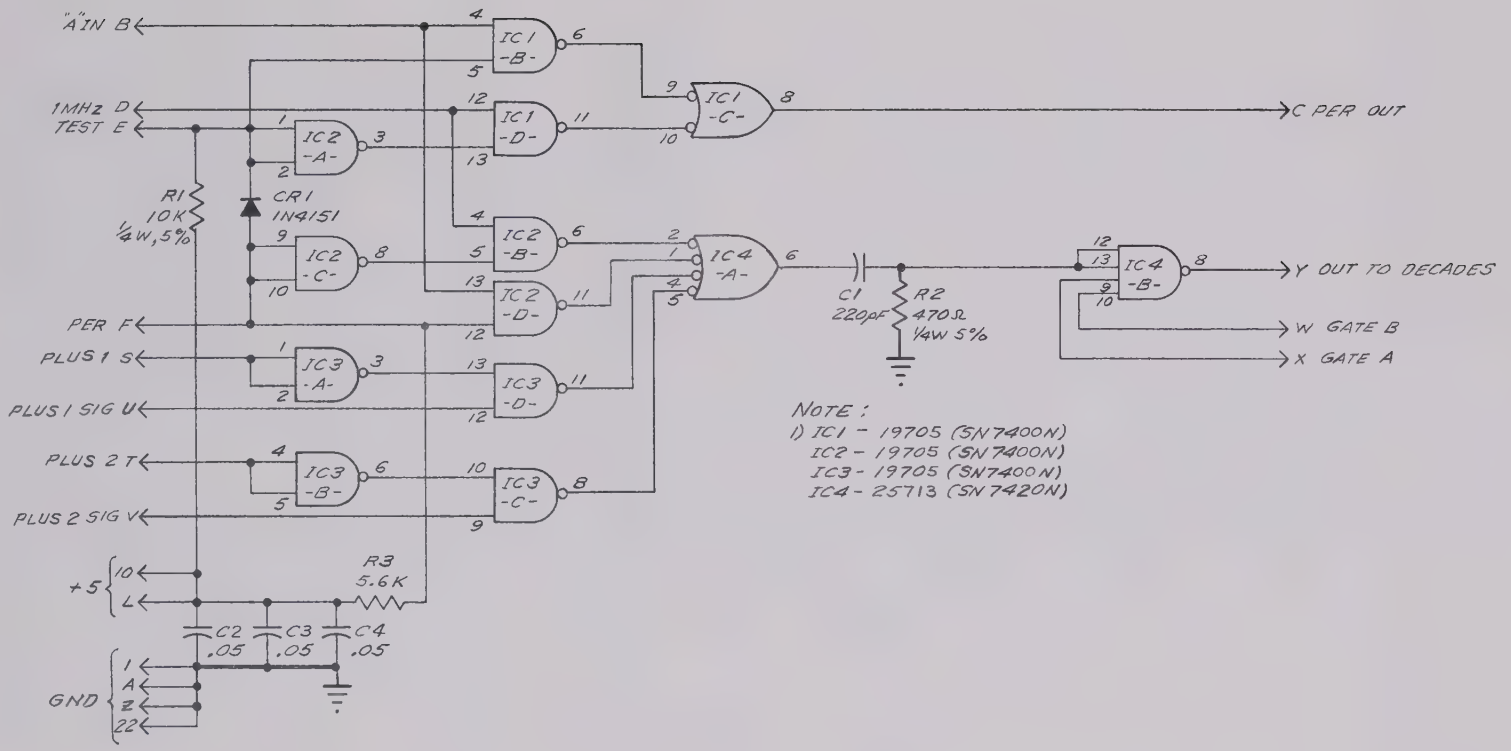
1) RESISTORS:
   POWER ——— 1/4 W.
   TOL. ——— 5%.

2) CAPACITORS:
   MORE THAN ONE IN pF.
   LESS " " " μF.

SYSTRON DONNER CORPORATION CONCORD, CALIFORNIA	SCHEMATIC - AMP & SHAPER PC ASS'Y
MATERIAL	DWG NO. 25345 ISSUE A1

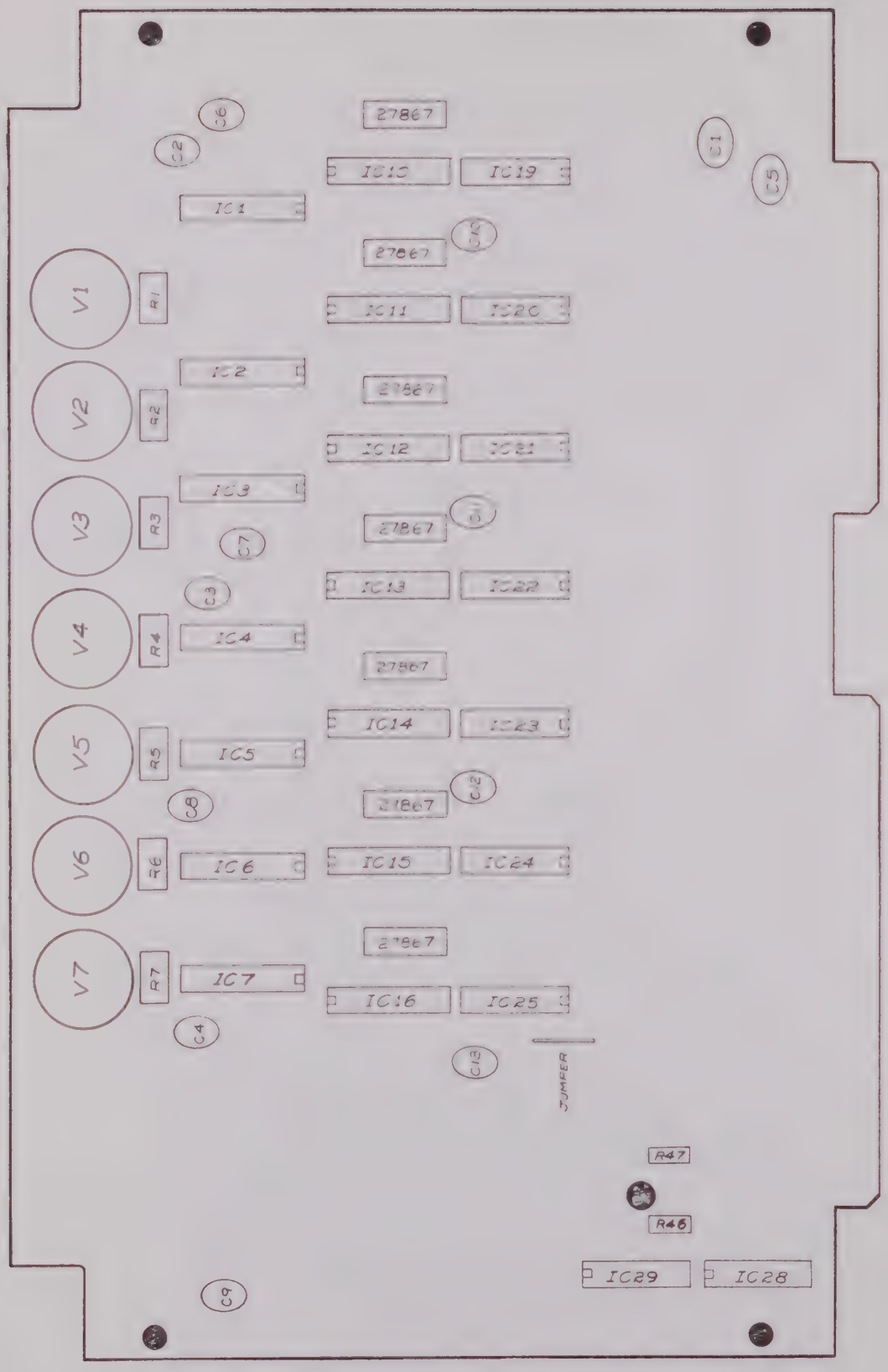


Count Gates PC Board
Part Number 25373
Access: Top Cover

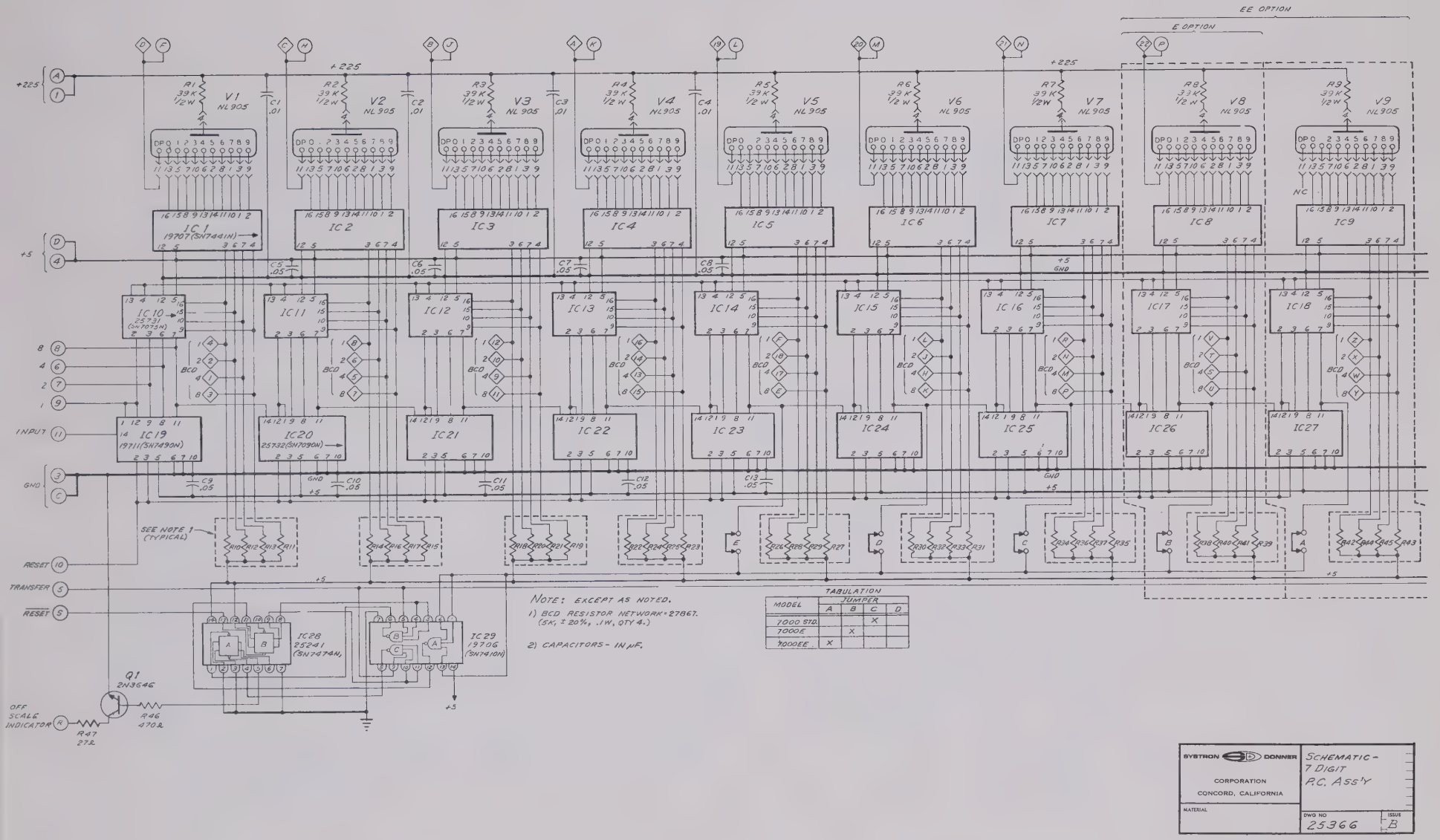


NOTE:
1) IC1 - 19705 (SN7400N)
IC2 - 19705 (SN7400N)
IC3 - 19705 (SN7400N)
IC4 - 25713 (SN7420N)

SYSTRON DONNER CORPORATION CONCORD, CALIFORNIA	SCHEMATIC- COUNT GATES PC ASSY
MATERIAL	DWG NO. 25370 ISSUE A



7 Digit PC Board
Part Number 25369
Access: Top Cover



NOTE: EXCEPT AS NOTED.

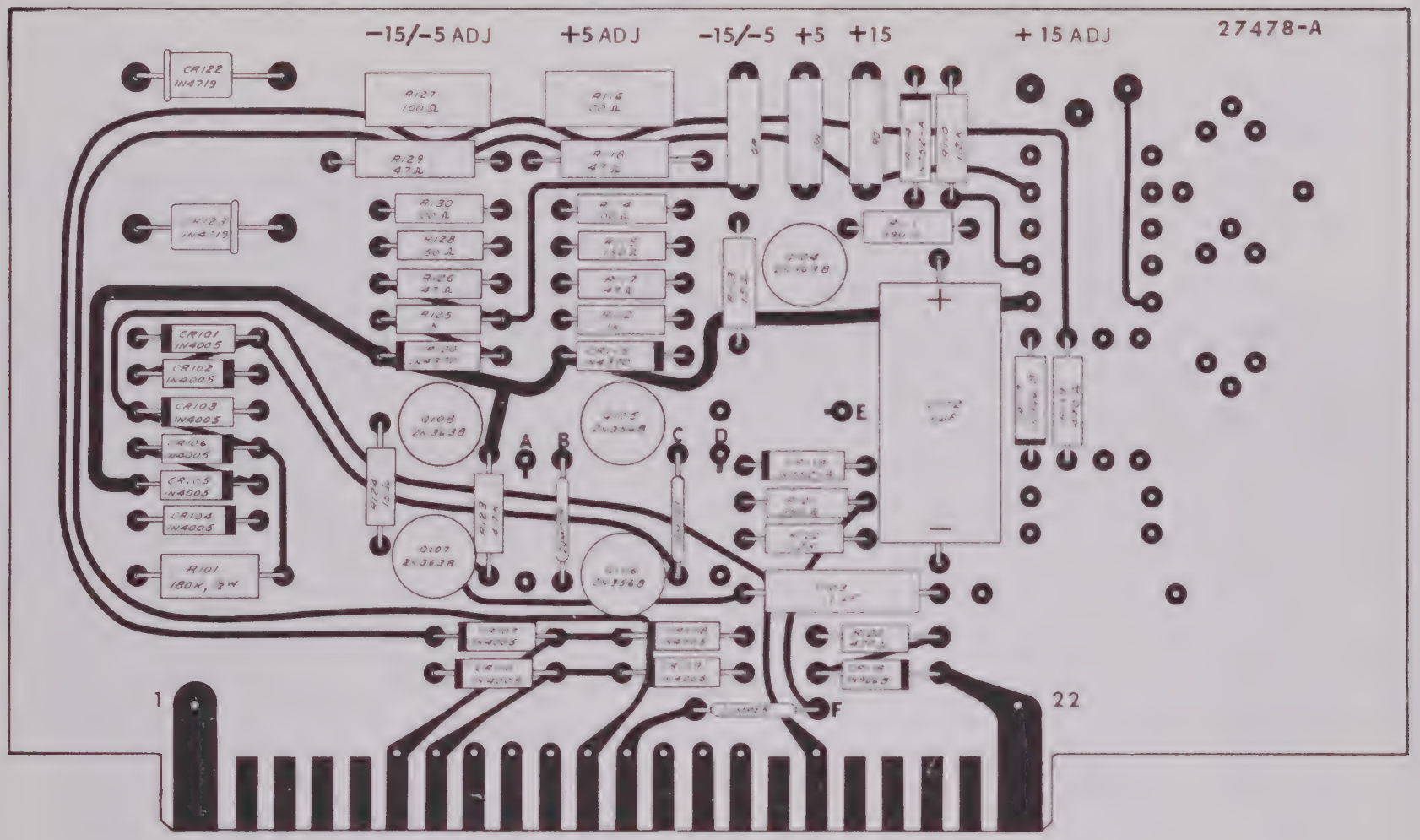
1) BCD RESISTOR NETWORK=27867. (5K, ±20%, .1W, QTY 4.)

2) CAPACITORS - IN μF.

TABULATION

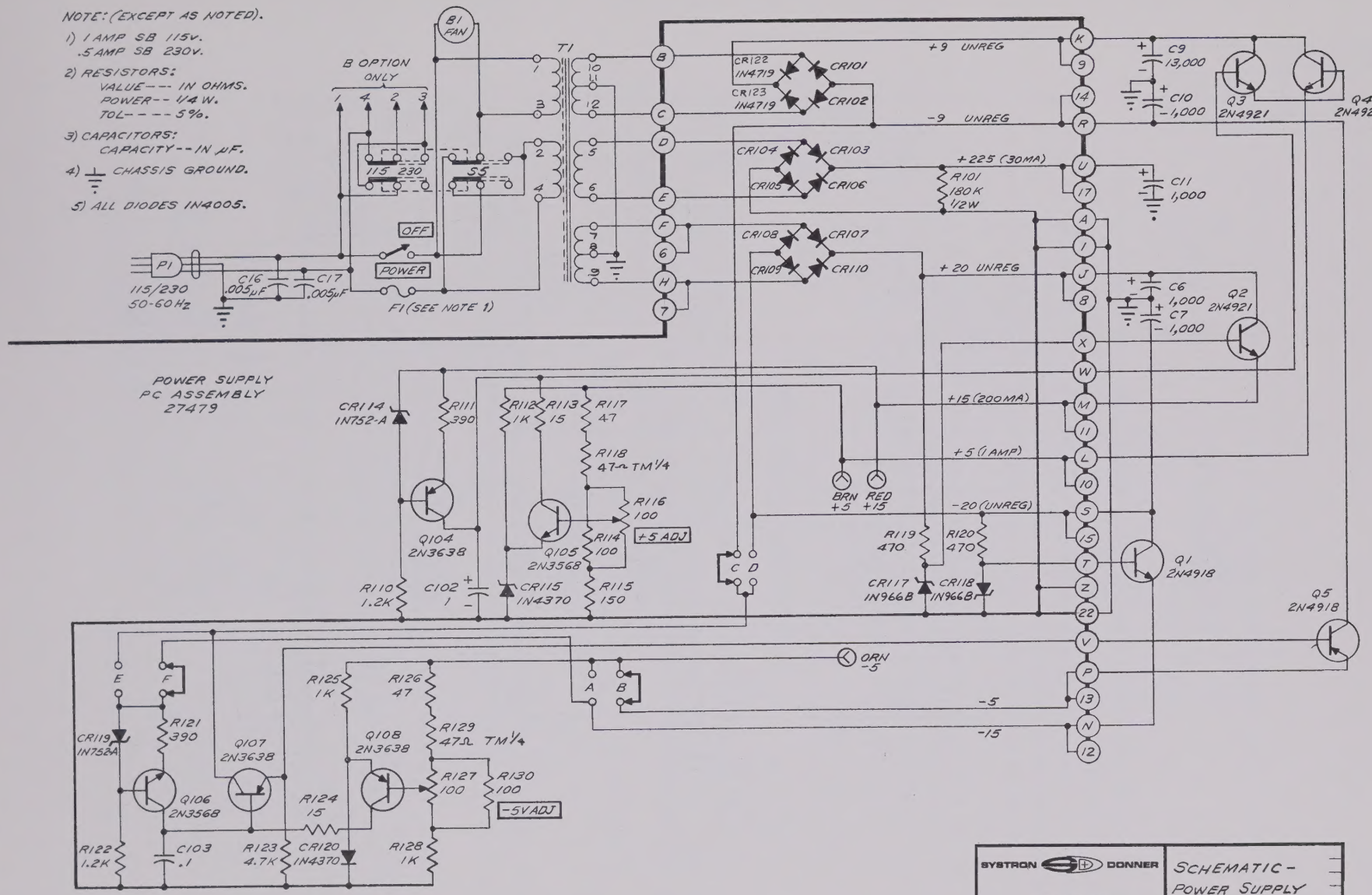
MODEL	JUMPER A	B	C	D
1000 STD.			X	
1000E		X		
1000EE	X			

SYSTRON DONNER CORPORATION CONCORD, CALIFORNIA	SCHEMATIC - 7 DIGIT P.C. ASS'Y
MATERIAL	DWG NO 25366 ISSUE B

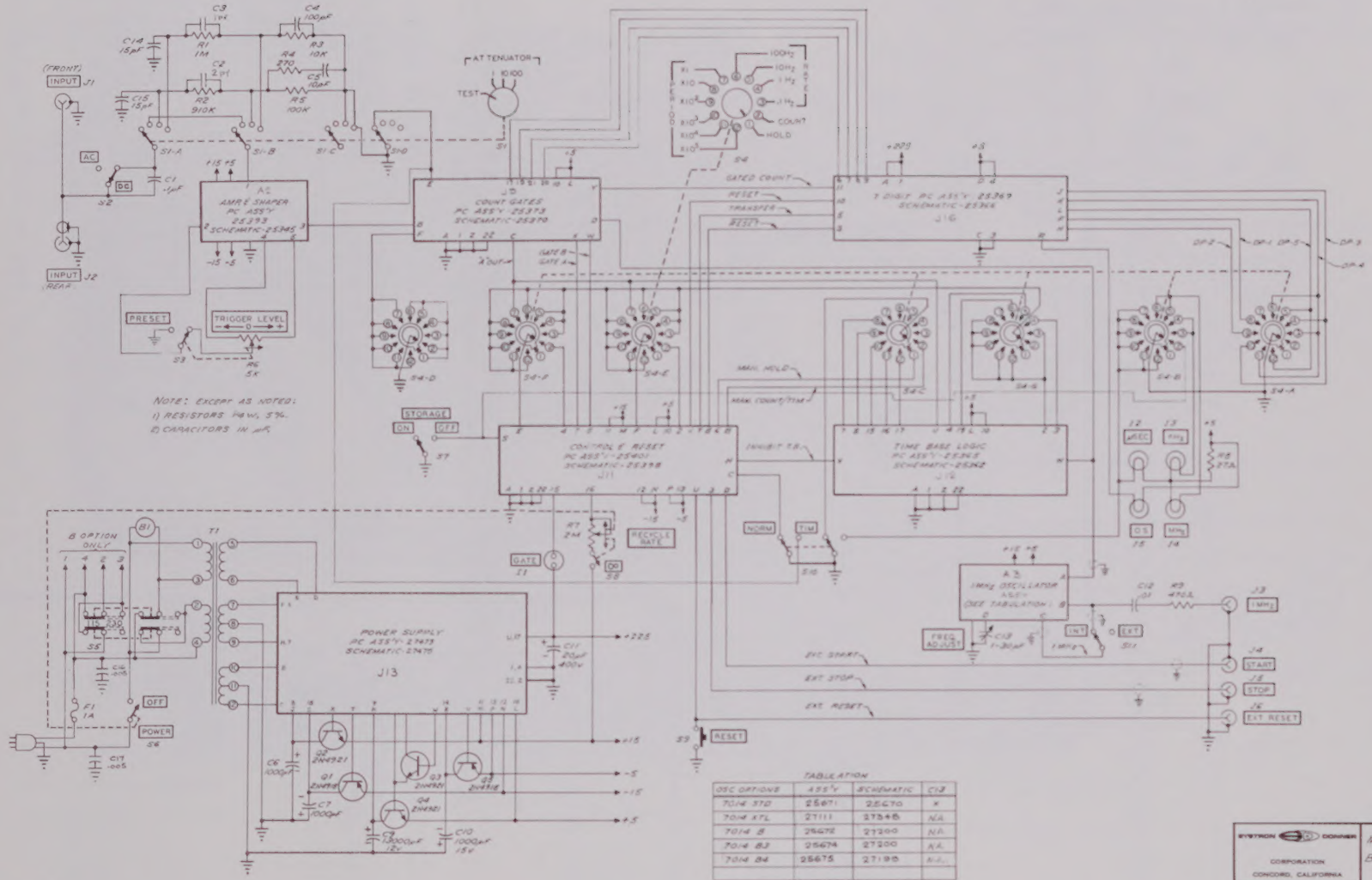


Power Supply PC Board

Access: Top Cover



SYSTRON DONNER CORPORATION CONCORD, CALIFORNIA	SCHEMATIC - POWER SUPPLY P.C. ASSY	
MATERIAL	DWG NO. 27475	ISSUE A



NOTE: EXCEPT AS NOTED:
1) RESISTORS ¼W, 5%.
2) CAPACITORS IN μF.

TABULATION

OSC OPTIONS	ASS'Y	SCHEMATIC	C13
7014 STD	25671	25670	K
7014 XTL	27111	27346	N.A.
7014 B	25672	27200	N.A.
7014 B3	25674	27200	N.A.
7014 B4	25675	27198	N.A.

EVERETT DOVER CORPORATION CONCORD, CALIFORNIA	MODEL 7014 BLOCK DIAGRAM
	DWG NO. 25697 REV B

WARRANTY

Systron-Donner instruments are warranted during a period of one year from date of shipment to original purchaser to be free from defects in material and workmanship. This warranty does not apply to vacuum tubes, except as they are warranted by tube manufacturers. The liability of Seller under this warranty is limited to replacing or repairing any instrument or component thereof which is returned by Buyer at his expense during such period and which has not been subjected to misuse, neglect, improper installations, repair, alteration, or accident. Seller shall have the right of final determination as to the existence and cause of a defect. In no event shall Seller be liable for collateral or consequential damages. This warranty is in lieu of any other warranty, express, implied or statutory, and no agreement extending or modifying it will be binding upon Seller unless in writing and signed by a duly authorized officer.

RECEIVING INSPECTION

Every Systron Donner instrument is carefully inspected and is in perfect working order at the time of shipment. Each instrument should be checked as soon as received. If the unit is damaged in any way or fails to operate, a claim should immediately be filed with the transportation company.

REPAIRS

Whenever a Systron-Donner instrument requires service, the nearest Systron-Donner representative should be contacted; all representatives will provide immediate service or arrange factory returns when necessary.

Please specify both model and serial number in all correspondence concerning Systron-Donner instruments. Address all inquiries on operation or applications to your nearest sales representative or Sales Manager, Instruments, Systron-Donner Corporation, 888 Galindo Street, Concord, California.